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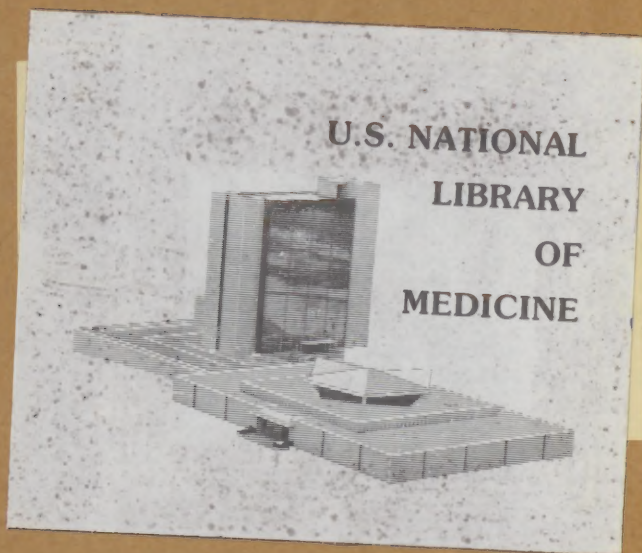
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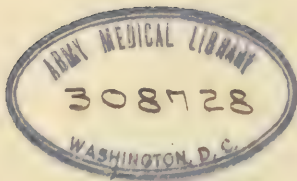
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TORONTO

FOOD PRODUCTS

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PREFACE

BOTH food legislation and the scientific investigation of certain important aspects of the composition and value of food have undergone an exceptionally rapid development during the past few years. In this volume it is sought to incorporate in the subject matter of a general study of foods the results of these recent advances which heretofore have been too widely scattered to be readily accessible.

The general plan is to devote a chapter to each important type of food covering (1) an account of its production and preparation for market with such brief statistical data as will indicate the relative economic importance of the industry, (2) the proximate composition and general food value, (3) questions of sanitation, inspection, and standards of purity, (4) special characteristics of composition, digestibility, nutritive value and place in the diet. The study of milk affords opportunity for the correlation of all these aspects and may therefore serve to set standards for the study of the other types of food. Since a detailed discussion of each aspect under every article of food would have made the present volume too large for its main purpose, it has seemed best to distribute the emphasis differently in different chapters according to the nature of the food and the state of development of the industry. Lists of references appended to the different chapters will facilitate the extension of the work covered by the text along either chemical, economic, sanitary, or nutritional lines.

To add to the usefulness of the book for reference the tables of composition of foods have been made as complete as is prac-

ticable and a considerable compilation of data relating to food legislation and inspection has also been included in the appendix.

The author would here make grateful acknowledgment to the authorities whose lectures and reports have been freely quoted in describing the different food industries, and to many friends for helpful suggestions. Special thanks are due to his colleague Mr. A. W. Thomas and his former students Miss Lucy H. Gillett and Miss Ethel Ronzone each of whom has critically examined the entire work either in manuscript or in proof. Corrections or suggestions from others who may use the book will be appreciated.

H. C. S.

JULY, 1914.

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FOOD PRODUCTS

CHAPTER I

THE PRINCIPAL CONSTITUENTS AND FUNCTIONS OF FOOD

THROUGH the food the body obtains the substances which enter into its structure, which yield energy for its activities, and which regulate the processes essential to life and health.

Most articles of food contain *water*, as shown by the fact that they lose weight on drying. The dry residue consists mainly of *combustible matters*, but when these are burned off there usually remains some *ash*.

The combustible portion of the food may comprise a variety of organic compounds, but in the great majority of staple foods nearly all of the organic matter is found to be comprised within three groups of substances — *the carbohydrates* (such as the starches and sugars), *the fats* (such as those of butter, olive oil, corn oil, lard, and meat fat), and *the proteins* (such as the albumin of egg, the curd of milk or cheese, the muscle fiber of meat, the gluten of flour or bread). Meat extracts and many vegetables contain nitrogen compounds simpler than proteins, the so-called “nitrogenous extractives” or “nitrogenous non-proteins.” In green vegetables and berries a small part of the organic material consists of coloring matters, resins, and waxes. In the main, however, the organic matter of food consists essentially of proteins, fats, and carbohydrates, and in the methods commonly used for the routine analysis of foods the minor organic constituents are apt to be ignored, all nitrogenous

material being counted as protein; all material soluble in ether, as fat; and all other organic material, as carbohydrate.

If we consider the composition of food materials in terms of elements rather than compounds, we find that the plant and animal tissues which we use as food are composed mainly of the same twelve chemical elements which chiefly compose the tissues of the body; namely, carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, chlorine, sodium, potassium, calcium, magnesium, and iron. Iodine, fluorine, and probably silicon and manganese are also essential to the body and so must be supplied by the food; but the amounts of these latter elements are so small that they are usually scarcely measurable by the ordinary methods of food analysis.

While the ash of foods is composed of relatively simple inorganic (mineral) compounds such as the chlorides, phosphates, sulphates, and carbonates of sodium, potassium, calcium, magnesium, and iron, it does not follow that these elements exist in the form of the same inorganic compounds in the food. In many cases the inorganic compounds found in the ash are to a large extent formed during the burning of the food, the base-forming elements having existed in combination with organic acids or with proteins, while the acid radicles may also have existed in organic combination or may have been formed by the oxidation of the sulphur, phosphorus, or carbon of the organic matter.

The principal chemical elements of foods and the most important kinds of compounds in which they are found may therefore be summarized as follows:

Hydrogen	}	forming Water .
Oxygen		

Carbon	}	forming Carbohydrates, Fats (and sometimes Organic Acids).
Hydrogen		
Oxygen		

Carbon	} forming Proteins.
Hydrogen	
Oxygen	
Nitrogen	
Sulphur	
Phosphorus	
(sometimes)	
Iron	}
(sometimes)	

Sulphur	} forming Ash Constituents which exist partly as mineral salts and partly in combination with carbohydrates, fats, proteins, and other organic compounds.
Phosphorus	
Chlorine	
Sodium	
Potassium	
Calcium	
Magnesium	
Iron	}

The *ultimate composition* of a food is its composition as expressed in terms of the chemical elements into which it might ultimately be resolved, — carbon, hydrogen, oxygen, nitrogen, sulphur, etc.

The *proximate composition* is the composition in terms of the compounds actually present — proteins, fats, carbohydrates, mineral salts, water. These five groups of compounds have sometimes been called the “proximate principles” of food, or the “five food principles.” As a precaution against ambiguity this use of the term “principles” is now generally avoided, but there is frequent occasion to use the terms “ultimate” and “proximate” in speaking of the composition and analysis of foods and it is well to keep the exact chemical significances of these terms in mind. The word “proximate” must not be confused with “approximate.”

Food materials and foodstuffs. The term “food materials” is

synonymous with the expression "articles of foods." Thus bread, meat, eggs, milk, are spoken of as food materials. The term "food-stuffs" as a scientific term, and as it will be used in this work, means the stuffs that foods are made of, or, in the terms which we have been using, the substances of which the food materials are composed. Thus the proteins, fats, and carbohydrates and the various organic and inorganic compounds of phosphorus, potassium, iron, etc., which occur in food materials are food-stuffs.

The chemistry and nutritive significance of the foodstuffs, both organic and inorganic, has been discussed by the writer in another volume (*Chemistry of Food and Nutrition*) and cannot be repeated here in any detail. A brief summary of some of the facts having most relation to what follows in later chapters may, however, be advantageous at this point.

Carbohydrates. The carbohydrates include the simple sugars and all the substances which can be split (by hydrolysis) into simple sugars. The simple sugars, having only one sugar radicle in the molecule, are called "mono-saccharides." Sugars whose molecules contain two sugar radicles, and from each molecule of which two molecules of monosaccharide can be obtained by hydrolysis, are called disaccharides. Substances like starch and dextrin which can be hydrolyzed to simple sugars but which are of high molecular weight, each molecule containing many monosaccharide radicles, are called polysaccharides.

The monosaccharides are given group names according to the number of carbon atoms in the molecule, as will be seen in the classification which follows:

Monosaccharides

Hexoses ($C_6H_{12}O_6$)

Glucose (dextrose, grape sugar, starch sugar)

Fructose (levulose, fruit sugar)

Galactose

Mannose

Pentoses ($C_5H_{10}O_5$)

Arabinose

Xylose

Disaccharides ($C_{12}H_{22}O_{11}$)

Sucrose (cane sugar, saccharose)

Lactose (milk sugar)

Maltose (malt sugar)

Trisaccharide ($C_{18}H_{32}O_{16}$)

Raffinose (meletriase)

Polysaccharides

Hexosans ($C_6H_{10}O_5$)_x

Starch

Dextrin

Glycogen

Inulin

Galactan

Mannan

Cellulose

Pentosans ($C_5H_8O_4$)_x

Araban

Xylan

Some of these carbohydrates are of very great, and others of relatively little, practical importance.

Glucose is widely distributed in nature, occurring abundantly in many fruits and plant juices, often mixed with other sugars. Since most of the other carbohydrates yield glucose when split by the digestive ferments the total amount of glucose which is absorbed into the body is much larger than that of any other sugar. Normal blood always contains glucose (usually about 0.1 per cent) which is constantly being burned to yield energy to the body. Any surplus of glucose absorbed from the digestive tract is normally stored in the body in the form of glycogen which latter is converted back into glucose as needed to replace that which has been burned. Com-

mercially glucose is made by hydrolysis of starch as explained in Chapter VIII.

Fructose occurs with glucose in plant juices and especially in fruits and honey. It is formed along with an equal weight of glucose when cane sugar is hydrolyzed; hence its occurrence in molasses and sirups as well as honey. (See Chapter XI.) When cane sugar is eaten it is not absorbed as such, but is changed into equal parts of glucose and fructose in digestion. The fructose absorbed into the body serves the same purposes as glucose and like glucose may be changed into glycogen for storage. Glucose and fructose are the only monosaccharides which occur as such in foods.

Galactose does not occur free in nature or in commercial food products, but as a product of digestion of milk sugar it is of some importance in nutrition. It is utilized like glucose in the body.

Mannose also is not found free. It may result from the digestion of mannan, occurring, for example, in certain Japanese foods, and when absorbed into the blood it is utilized like glucose or galactose.

Arabinose and **xylose** are not found free in nature nor in commercial food products.

Sucrose occurs commonly in the vegetable kingdom, being found in considerable quantity in many familiar fruits and vegetables. Usually these sweet fruits and plant juices contain glucose and fructose along with the sucrose, and also other substances which make it difficult to separate the sucrose in crystalline form. The juices of the sugar cane, the sugar beet, and to a less extent certain maple and palm trees, contain enough sucrose and little enough of other substances to make it practicable to manufacture sugar from them commercially. (See Chapter XI.) On hydrolysis a molecule of sucrose yields one molecule each of glucose and fructose. The process is often called "inversion" and the product "invert sugar." When eaten, sucrose is digested into glucose and fructose, the nutritive functions of which have been mentioned above.

Lactose occurs in milk and is made commercially from the whey of milk used in the manufacture of cheese or casein. In the body lactose is digested into equal parts of glucose and galactose, the nutritive functions of which have been noted above.

Maltose occurs in malted or germinated grains, in malt extracts, etc., but the amount of maltose eaten as such is not likely to be large. It is formed in quantity by the digestion of starch by the saliva or the pancreatic juice. Maltose, however, whether eaten or formed in the course of digestion is not absorbed as such to any important extent, but is split by a digestive ferment of the intestinal juice, each molecule of maltose yielding two molecules of glucose.

Raffinose occurs in small quantity in the germs of several seeds. It is of no practical importance for its own sake, but occasionally acquires technical importance through developing in sugar beets (especially when the latter are unhealthy or injured) in sufficient amount to interfere with the crystallization of the sucrose. When hydrolyzed one molecule of raffinose yields one molecule each of glucose, fructose, and galactose.

Starch is the chief form in which most plants store their reserve supply of carbohydrate material. It constitutes over one half of the solid matter of the cereal grains and an even larger proportion of the total solids of some other starchy foods such as potatoes, bananas, and chestnuts. In the processes of digestion, starch (especially when it has been cooked) is changed to maltose and the latter (as stated above) into glucose. In addition to the direct use of starchy materials as food, much starch is separated on an industrial scale (Chapter VIII) and used as such or as a source of dextrin, maltose, commercial glucose, or fermentation products.

Raw starch is easily seen under the microscope to consist of distinct granules, the size and shape of which differ greatly in the starches formed in different types of plants. Figure 1 represents starch granules from potato, wheat, and corn (maize), all magnified in the same proportion.

Dextrins are formed from starch by the action of ferments, acids, or heat. Although usually represented by the same empirical formula as starch, the dextrins appear in general as



FIG. 1. — Starch granules magnified 300 diameters.

intermediary products in the hydrolysis of starch to maltose or glucose; hence no further discussion is required here.

Glycogen is the chief reserve form of carbohydrate in animals as starch is in plants. For this reason and because of its physical properties and its chemical relationship to maltose and glucose, it is often called “animal starch.” It is stored principally in the liver and to a small extent in the muscles.

Inulin is a white powdery substance, found in a few vegetables, which on hydrolysis yields fructose. It is of practically no importance as food.

Galactans are found in small quantity in many plants and in larger amounts in the seeds of legumes. On hydrolysis they yield galactose.

Mannans, yielding mannose on hydrolysis, occur in some food materials, but are not of practical importance in this country.

Cellulose is familiar as a woody or fibrous material occurring in the cell walls of all vegetable tissues. It yields glucose on hydrolysis, but is not digested to a sufficient extent to make it of much nutritive value to man, though it is often of value in giving proper bulk to the diet.

The pentosans, araban and xylan which yield arabinose and xylose respectively on hydrolysis, are quite widely distributed among plant products, but as a rule occur only in small quantities in those parts of plants which are commonly used as human food.

From what has been said above it will be clear that the various digestible carbohydrates of the food, having been split by the digestive ferments to monosaccharide, are absorbed into the blood. Any surplus is stored temporarily in the form of glycogen, chiefly in the liver, though to some extent in the muscles. The glucose which circulates in the blood is burned in the muscles and other active tissues as fuel, the burned glucose being constantly replaced by new glucose derived from the stored glycogen so that under ordinary conditions the carbohydrate of the food is entirely burned as fuel. When more carbohydrate is received than is burned, the surplus is stored as glycogen but only to a limited extent, the total amount of glycogen which the body can store being estimated at less than one pound or only about as much carbohydrate as might be contained in the food of one day. A surplus of carbohydrate, in addition to being stored as glycogen, may also be converted into fat, and this transformation of carbohydrate into fat can be carried on to a very large extent and with almost no loss of energy. The energy value to the body of average carbohydrate in the food is 4.0 Calories per gram, or 1814 Calories per pound.

Organic acids. Some foods contain considerable quantities of organic acids or their salts. Oranges and lemons, for instance, are rich in citric acid; grapes contain potassium acid tartrate; apples and other fruits contain malic acid, and many fruits contain succinic acid. A few foods contain oxalic acid or oxalates, but these are probably of little food value. Fermented foods may contain appreciable quantities of lactic acid as in sauerkraut and sour milk, buttermilk, etc., or acetic acid as in vinegar.

With the exception of oxalic acid, these organic acids appear to be very readily burned in the body and doubtless their energy is used in practically the same way as the energy of the carbohydrates. The fuel values of some of these acids have been determined as follows: acetic acid, 3.5 Calories per gram; citric acid, 2.5 Calories per gram; lactic acid, 3.7 Calories per gram; succinic acid, 3.0 Calories per gram; tartaric acid, 1.7 Calories per gram. While these values are somewhat lower than those of the carbohydrates, it is not uncommon in reckoning the fuel value of a food to count the organic acid as carbohydrate, especially as in routine analyses the acids

are often not determined nor are the carbohydrates determined directly, but all of the material not found to be moisture, protein, fat, or ash is often considered to be carbohydrate for the purposes of ordinary estimations of food values.

Fats

The fats are all glycerides; that is, substances consisting of combinations of glycerol (commercially called "glycerin") with fatty acids. Many of these fatty acids belong chemically to the same series with acetic acid. The members of this series occurring naturally in fats are butyric acid, $C_4H_8O_2$; caproic acid, $C_6H_{12}O_2$; caprylic acid, $C_8H_{16}O_2$; capric acid, $C_{10}H_{20}O_2$; lauric acid, $C_{12}H_{24}O_2$; myristic acid, $C_{14}H_{28}O_2$; palmitic acid, $C_{16}H_{32}O_2$; stearic acid, $C_{18}H_{36}O_2$.

Butyric acid is a liquid which mixes in all proportions with water, alcohol, and ether, can be boiled without decomposition, and is readily volatile in steam.

With increasing molecular weight, the acids of this series regularly show increasing boiling or melting points, decreasing solubility, and become less volatile. Those up to capric acid are liquids at ordinary temperatures; those above are solids. The higher the molecular weight, the harder the solid. Stearic acid is a hard paraffin-like crystalline solid insoluble in water and only moderately soluble in alcohol and ether.

The properties of the fats themselves depend upon and run parallel with those of the fatty acids.

In addition to the fatty acids of the series to which acetic, butyric, and stearic acids belong, all of which are saturated compounds, there are several unsaturated fatty acids, capable of combining chemically with hydrogen, oxygen, or iodine by direct addition. The most important of these contain eighteen carbon atoms to the molecule and therefore resemble stearic acid in molecular size.

The most important of these unsaturated fatty acids are: oleic acid, $C_{18}H_{34}O_2$; linoleic acid, $C_{18}H_{32}O_2$; linolenic acid,

$C_{18}H_{30}O_2$. All of these acids and their glycerides are liquid at ordinary temperatures. Commercial fats consisting mainly of the glycerides of these acids are therefore liquids and are usually called oils. The chief chemical difference between olive oil and lard is that the former contains more *olein* (glyceride of oleic acid) and the latter more of *palmitin* and *stearin* (glycerides of palmitic and stearic acids). Olein or *linolein* (glyceride of linoleic acid) may be converted into stearin by direct chemical union with hydrogen, and this is now done on a commercial scale for the hardening of fatty oils so as to give them the consistency of lard. (See Chapter X.)

The body fat of man and of the animals commonly used as food consists chiefly of glycerides of palmitic, stearic, and oleic acids. Since palmitin and stearin are solids, while olein is a liquid, the hardness or softness of these fats is principally due to the proportion of olein which they contain. Butter fat contains all of the fatty acids listed above in the series from butyric to stearic acid and is distinguished from the other food fats principally by this fact. Olive oil consists chiefly of palmitin, stearin, and olein, but contains much more olein and much less stearin than the ordinary solid fats. In cottonseed oil, sesame oil, and other seed oils used as food, the quantities of palmitin and stearin are still smaller and, in addition to large quantities of olein, considerable quantities of linolein and in some cases even linolenin may occur.

In ordinary food analysis, fat is determined by extraction with ether. All ether-soluble substances are therefore likely to be counted as fat. In this way some small quantities of materials of less food value are likely to be counted along with the fat of the food. The commercial food fats are nearly free from other substances (except that butter contains water and salt) and have therefore nearly the same composition and food value. Descriptions of the edible fats and oils and discussion of their digestibility and place in the diet will be found in Chapter X.

The fat of the food after digestion and absorption is again found in the blood in the form of glycerides or neutral fat which disappears partly by being burned in the muscles and other active tissues where it is used as fuel for the same purposes as carbohydrate and if in excess of the fuel requirements of the body, the fat obtained from the food may also be stored in the tissues. The body fat obtained thus directly from the food may show somewhat different characters from the fat which has been formed in the body from carbohydrate, but its nutritive relations appear to be exactly the same. In either case, the fat thus stored in the body may be drawn upon for use as fuel at any future time when the energy requirements of the body demand it.

The energy value to the body of average food fat is 9.0 Calories per gram, or 4082 Calories per pound.

Proteins (Nitrogen Compounds)

Among the nitrogenous constituents of foods, the proteins usually so far predominate that the term protein is often used as practically synonymous with the nitrogen compounds of food materials. For this reason, and because the great majority of proteins contain from 15 to 18 per cent, averaging about 16 per cent, of nitrogen, the protein content of food materials is usually estimated by determining nitrogen and multiplying the percentage of nitrogen found by 6.25.

The proteins are very complex substances and in no case is the chemical constitution of a natural protein fully and exactly known. It has, however, been determined that the typical proteins are essentially anhydrides of amino acids. Thus the relation of the protein molecule to the amino acids, from which it is derived and into which it can be resolved, is analogous to the relation of starch to glucose. There is, however, this striking difference: that the molecules of monosaccharide derived from the complete hydrolysis of the starch are all alike

(glucose), whereas the complete hydrolysis of a protein always yields several different amino acids, usually from twelve to fifteen.

The names ¹ of the amino acids commonly met as products of hydrolysis of proteins are: glycine (glycocoll), alanine, serine, valine, leucine, proline, phenylalanine, tyrosine, aspartic acid, glutamic (glutaminic) acid, lysine, arginine, histidine, tryptophan, cystine. The strict chemical names and structural formulæ of these amino acids are given in *Chemistry of Food and Nutrition*, Chapter I.

Classification. There has been considerable confusion in the classification and terminology of the proteins, and even in the publications of the present day, the same terms may sometimes be found employed with different meanings by different writers. The classification now generally approved is as follows:

I. Simple proteins. Protein substances which yield only amino acids or their derivatives on hydrolysis.

(a) *Albumins.* Simple proteins soluble in pure water and coagulable by heat. Examples: egg albumen, lact-albumen (milk), serum albumen (blood), leucosin (wheat), legumelin (peas).

(b) *Globulins.* Simple proteins insoluble in pure water, but soluble in neutral salt solutions. Examples: muscle globulin, serum globulin (blood), edestin (wheat, hemp seed, and other seeds), phaseolin (beans), legumin (beans and peas), vignin (cow peas), tuberin (potato), amandin (almonds), excelsin (Brazil nuts).

(c) *Glutelins.* Simple proteins insoluble in all neutral solvents, but readily soluble in very dilute acids and alkalies. The best known and most important member of this group is the glutenin of wheat.

(d) *Alcohol soluble proteins.* Simple proteins soluble in rela-

¹ The names of the amino acids may be spelled either with or without the final *e*, e.g., glycine or glycin, alanine or alalin.

tively strong alcohol (70-80 per cent) but insoluble in water, absolute alcohol, and other neutral solvents. Examples: gliadin (wheat), zein (corn), hordein (barley).

(e) *Albuminoids*. These are the simple proteins characteristic of the skeletal structures of animals (for which reason they are also called scleroproteins) and also of the external protective tissues such as the skin, hair, etc. None of these proteins is used for food in the natural state, but collagen when boiled with water yields gelatin so that these two are of considerable importance in food chemistry.

(f) *Histones*. Soluble in water, and insoluble in very dilute ammonia, and in the absence of ammonium salts insoluble even in an excess of ammonia; yield precipitates with solutions of other proteins and a coagulum on heating which is easily soluble in very dilute acids. On hydrolysis they yield several amino acids among which the basic ones predominate. The only members of this group which have any considerable importance as food are the thymus histone and the globin derived from the hemoglobin of the blood.

(g) *Protamines*. These are simpler substances than the preceding groups, are soluble in water, uncoagulable by heat, possess strong basic properties and on hydrolysis yield a few amino acids among which the basic amino acids greatly predominate. They are of no importance as food.

II. Conjugated proteins. Substances which contain the protein molecule united to some other molecule or molecules otherwise than as a salt.

(a) *Nucleoproteins*. Compounds of one or more protein molecules with nucleic acid. Examples of the nucleic acids thus found united with proteins are thymo-nucleic acid (thymus gland), tritico-nucleic acid (wheat germ).

(b) *Glycoproteins*. Compounds of the protein molecule with a substance or substances containing a carbohydrate group other than a nucleic acid. Example: mucins.

(c) *Phosphoproteins*. Compounds in which the phosphorus is in organic union with the protein molecule otherwise than in a nucleic acid or lecithin. Examples: caseinogen (milk), ovovitellin (egg yolk).

(d) *Hemoglobins*. Compounds of the protein molecule with hematin or some similar substance. Example: hemoglobin of blood. (The redness of meat is due chiefly to the hemoglobin of the blood which the meat still retains.)

(e) *Lecithoproteins*. Compounds of the protein molecule with lecithins or related substances.

III. Derived proteins.

1. *Primary protein derivatives*. Derivatives of the protein molecule apparently formed through hydrolytic changes which involve only slight alterations of the protein molecule.

(a) *Proteans*. Insoluble products which apparently result from the incipient action of water, very dilute acids or enzymes. Examples: casein (curdled milk), fibrin (coagulated blood).

(b) *Metaproteins*. Products of the further action of acids and alkalis whereby the molecule is sufficiently altered to form proteins soluble in very weak acids and alkalis, but insoluble in neutral solvents. This group includes the substances which have been called "acid proteins," "acid albumins," "syntonin," "alkali proteins," "alkali albumins," and "albuminates."

(c) *Coagulated proteins*. Insoluble products which result from (1) the action of heat on protein solutions, or (2) the action of alcohol on the protein. Example: cooked egg albumin, or egg albumin precipitated by means of alcohol.

2. *Secondary protein derivatives*. Products of the further hydrolytic cleavage of the protein molecule.

(a) *Proteoses*. Soluble in water, not coagulable by heat, precipitated by saturating their solutions with ammonium sulphate or zinc sulphate. The products commercially known as "peptones" consist largely of proteoses.

(b) *Peptones*. Soluble in water, not coagulable by heat, and not precipitated by saturating their solutions with ammonium sulphate or zinc sulphate. These represent a further stage of cleavage than the proteoses.

(c) *Peptids*. Definitely characterized combinations of two or more amino acids. An anhydride of two amino acid radicles is called a "di-peptid"; one having three amino acid radicles, a "tri-peptid"; etc. Peptids result from the further hydrolytic cleavage of the peptones. Many peptids have also been made in the laboratory by the linking together of amino acids.

Substances simpler than the peptones but containing several amino acid radicles are often called "polypeptids."

Behavior in Nutrition.¹ The digestion products of the protein absorbed from the digestive tract into the blood stream are rapidly distributed through the body and taken up by the muscles and other tissues. A part of the nitrogenous material thus received may be utilized for the growth or repair of tissue material; the remainder is split up, the nitrogen being eliminated chiefly as urea and the non-nitrogenous residue being either burned as fuel or converted into carbohydrate or fat.

It should be kept in mind that in the full-grown, well-nourished organism, no increase of protein tissue ordinarily occurs; hence all the protein received from the food is burned as fuel, whether it first serves for the repair of the body tissue or not. The exact nature of the repair process in the tissues is not fully known. It is also uncertain to what extent the food must supply the exact amount of each individual amino acid which is to enter into the constitution of the body proteins. It is certain that the body can make glycine (glycocoll), while it cannot make tryptophan (certainly at least not at a sufficient rate to meet its needs). Hence the protein of the food need not contain glycine radicles but must contain tryptophan radicles if it is to serve fully the nutritive requirements of the body. The evi-

¹ For fuller discussion, see *Chemistry of Food and Nutrition*, Chapter IV.

dence in regard to the ability or inability of the body to make certain other amino acids is less clear. It is possible that this ability may vary with the species and it is altogether probable that it differs with age and development, since Osborne and Mendel have found that a protein which does not furnish the amino acid lysin may serve as the sole nitrogenous food for a full-grown animal but does not support growth. The subject is still under active investigation and attempts to generalize at this time would be premature, but some further discussion will be found in Chapters III and VIII. The energy value to the body of average food protein is 4.0 Calories per gram, or 1814 Calories per pound.

Ash Constituents

Sulphur compounds. Sulphur occurs in the food, as it does in the body, chiefly as a constituent of proteins. Since sulphur is essential to the constitution of the body proteins, it is obviously important that sufficient of this element shall be supplied by the food; but all food proteins also contain sulphur and though the percentages of sulphur in individual proteins show considerable differences, the different proteins of the same food material usually tend to balance each other in this respect so that the sulphur content of the total protein (or the ratio of sulphur to nitrogen) is about the same for most staple foods as for the body.

Hence it is believed that under ordinary conditions food which supplies adequate protein will thereby supply adequate sulphur so that sulphur need not ordinarily be considered as a separate factor in determining food values, but may usually be regarded as sufficiently provided for when the protein requirement is covered.

When the digestion products of the food proteins are burned in the body, the greater part of the sulphur is oxidized to sulphuric acid and excreted as sulphates.

Phosphorus compounds. Phosphorus compounds are essential to all the tissues of the body and it is important that they be adequately supplied by the food.

The various articles of food differ greatly in phosphorus content, nor does the amount of phosphorus run even approximately parallel with the protein content (as does the sulphur). Hence the phosphorus compounds of food materials should be carefully considered in forming judgments of nutritive values.

The phosphorus compounds of foods may be grouped into four general classes, one inorganic and three organic: (1) inorganic phosphates; (2) phosphorized proteins, including the phosphoproteins such as casein and the nucleoproteins characteristic of cell nuclei; (3) phosphorized fats or phospholipines, such as egg lecithin; (4) combinations of phosphoric acid with carbohydrates or with closely related substances such as inosite.

Some of the organic compounds of phosphorus are believed to be of greater food value than the simple phosphates.

All three groups of organic phosphorus compounds are more or less completely oxidized in the body, the phosphorus being finally excreted almost entirely in the form of phosphate. The phosphates of the food while entering and leaving the body in essentially the same form are nevertheless utilized in some very important nutritive functions such as furnishing material for bone structure and facilitating the maintenance of the normal neutrality of the blood and the body tissues.

Chlorides. Sodium chloride (common salt) is an essential and a prominent constituent of the blood and other body fluids. Carnivorous animals, eating the blood as well as the flesh of their prey, obtain in this way sufficient salt for their needs along with their organic foodstuffs; man and the herbivora take salt in addition to that naturally contained in their food. Salt is now such a cheap and popular condiment that it is commonly added to the food in such quantities as to make the natural chloride content of the food a matter of no practical consequence

While sodium chloride enters and leaves the body in the same form, it performs important functions. From it the hydrochloric acid of the gastric juice is made and chiefly to it the normal solvent power and osmotic pressure of the blood and other body fluids are due. The nature of these functions makes plain the imperative need for salt but also suggests that too much may be almost as objectionable as too little. The quantities of salt now commonly eaten are certainly larger than necessary and probably larger than are desirable.

Sodium, potassium, calcium, and magnesium. Sodium occurs in the food chiefly in the form of sodium chloride; potassium chiefly as phosphate, as salts of organic acids and perhaps in other organic combinations. The quantity of sodium present naturally in foods is usually not of great significance because of the large amounts in the form of common salt used as a condiment. Potassium is particularly abundant in many of the vegetables. To a certain extent sodium and potassium appear to act antagonistically in the body so that the large quantity of potassium taken in when such vegetables are eaten freely must be balanced by the taking of common salt.

There must also be maintained in the body a proper balance between sodium and calcium. For example, the rhythmical contraction and relaxation of heart muscle which constitutes the normal beating of the heart is dependent upon this muscle being bathed by a fluid containing the proper concentration and quantitative proportions of sodium and calcium.

In another direction there appears to be a somewhat analogous balancing of calcium and magnesium.

Since these elements are not only not interchangeable but are in some respects mutually antagonistic, it is evident that each must be supplied in sufficient quantity to permit the proper performance of its specific functions. In the case of sodium, the liberal use of salt as a condiment insures a more than ample supply. Potassium and magnesium appear to be sufficiently

abundant in most staple foods so that it is not usually necessary to specifically consider these elements in estimates of food values. Calcium is not always sufficiently abundant even when the food is freely chosen; hence the richness of a food in calcium is a factor affecting its value.

It was seen above that the sulphur entering the body in the protein of the food is mainly burned to sulphuric acid. This acid must of course be neutralized as fast as formed, and while the body has other resources which can be drawn upon to effect this neutralization, it appears to be distinctly advantageous that the food shall furnish a sufficient amount of the base-forming elements, in addition to those already in the form of mineral salts, to neutralize the fixed acids which are produced in metabolism. The most available source of base for this purpose is found in the compounds of the base-forming elements (chiefly potassium) with the organic acids or other organic matter of the foods. The significance of the balance between acid-forming and base-forming elements will be discussed more fully in Chapter IX.

Iron. Iron occurs in the food almost entirely in organic form as a constituent of certain proteins. The simpler forms, chiefly inorganic, in which iron is given medicinally do not seem to have the same nutritive effect as the food-iron.

The greater part of the iron in the body exists as an essential constituent of the hemoglobin of the blood, the remainder being chiefly in the chromatin substances of the cells. There is no considerable reserve store of inactive iron in the body corresponding to the stores of phosphorus and calcium in the bones. Hence if the food fails to furnish as much iron as is expended in the nutritive processes and excreted by the body, there must soon result a diminution of hemoglobin which if allowed to continue is marked by a greater or less degree of anæmia. Thus although only small amounts of iron are contained in the food or involved in the nutritive processes, its function as a building material for

the red blood cells is conspicuously important. Iron salts and other simple compounds of iron have long been used medicinally in the treatment of anæmia and it has often been held that the iron so used must enter directly into the construction of hemoglobin, but very extensive investigation indicates that this is not the case. The inorganic or medicinal iron appears to act as a stimulus to the blood-forming organs while the actual material from which the hemoglobin is made appears to be the iron-protein compounds of the food.

With our present knowledge we must look to the food and not to medicines or mineral waters for the supply of iron needed in normal nutrition and since freely chosen food does not always furnish enough iron to meet satisfactorily the requirements of the body it follows that the iron content is a factor of some importance in the consideration of food values.

Summary of the Functions of Food

Much the largest part of the total solids of the food is burned in the body and yields energy for the support of its activities. Even during growth most of the fat and carbohydrate and the greater part of the protein is so used.

Part of the protein of the food is used as a source of body protein, or, as it is often expressed, is used to build tissue. Several elements not contained in most proteins are also essential to the tissues of the body and these are derived from the so-called ash constituents of the food. The calcium and phosphorus of the bones, the potassium and phosphorus of the soft tissues, the iron of the red blood cells are just as necessary "building materials" as are the proteins, though the amounts required are much smaller.

Upon the presence in the body of salts derived from the food, either directly or as the result of its oxidation in the tissues, depend such important properties and processes as the solvent power and osmotic pressure of the body fluids, the elasticity of

the muscles, the maintenance of the normal neutrality or slight alkalescence of the blood and tissues.¹

These latter functions, and many others which might be mentioned as primarily dependent upon water and the salts, are hardly suggested by the phrase "tissue building," since they have to do not so much with the actual construction or repair of the tissues as with the regulation of the processes on which the nutrition of the body depends.

It may therefore be said that the functions of food are

- (1) to yield energy
- (2) to build tissue
- (3) to regulate body processes.

It is not to be inferred that any given food substance can be assigned once for all to some one of these three general functions. Thus the protein digestion products may serve both to build tissue and to yield energy; phosphates may serve both to build tissue and to assist in regulating the neutrality of the blood and tissues.

Moreover, it has very recently been established that certain important functions are performed by food constituents hitherto unknown and of which the amounts involved are so small that the chemical nature of the substances has not yet been fully established. Some of these substances appear to be nitrogen compounds and have received the group name *vitamines*. In other cases the active constituent has been described as a *lipoid*, that is, a fatlike substance. These little known, but apparently very significant, food constituents will receive further attention in the chapters which deal specifically with the different types of food.

¹The normal condition of the blood and tissues is described either as neutral or as slightly alkaline, according to the definition of neutrality used.

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CHAPTER II

FOOD LEGISLATION

Principles of Food Legislation

Food is more nearly a fixed requirement than most other necessities of life. The smaller the income the larger the percentage of it which must be spent for food. For the majority of the people it is approximately true that "half the struggle of life is a struggle for food." In this chapter we have to consider in a general way the necessity for legal control of the food industry and the chief features of the pure food laws.

At the present time, more than half the total value of natural products of the United States is represented by the food products whose annual value is about twice that of all other farm products and over twice that of the combined products of the mines and forests.

The products of the mines and forests may be subjected to more elaborate processes of manufacture and so may be increased in value in greater ratio before reaching the consumer than are the food products; but even so we find from the census returns that in value of finished as well as of natural products the food industries lead all others. Among the manufactures as classified by the United States Census, the greatest is that of slaughtering and meat packing. The annual product of the meat packing establishments exceeds in value that of the foundries and machine shops. The product of the flour and grist mills is about equal in value to that of either the rolling mills, the lumber mills, or the cotton mills of the country.

The enormous size to which many of the food manufacturing

establishments have grown during recent years (as for example a sugar refinery turning out daily from 1,000,000 to 3,000,000 pounds of sugar, or a butter factory producing 25,000 pounds of butter per day) makes it possible to effect great economies or make great advances, through what are apparently quite modest improvements in process or product. Hence the food industries are rapidly being brought under chemical control for the sake of economy in processes, improvement of staple products, and advantageous utilization of by-products.

Scientific control of the food industries has also been greatly stimulated in recent years by the rapidly growing tendency of consumers to fix requirements for food supplies through legislation.

With the development of modern industry population has concentrated in cities and towns to such an extent that the majority of people have ceased to produce any appreciable part of their own food or even to obtain it from their immediate neighbors. Most people must buy practically all of their food, and the food is brought from greater and greater distances and distributed under conditions which make it increasingly difficult for the consumer to exercise any direct individual control over the methods by which his food is produced and handled. When the majority of the people in any community find themselves in this position, they naturally tend to substitute for the individual control which is no longer feasible a collective control of their food supplies through legislation and official inspection.

In the United States the legal regulation of the food industry is accomplished partly through the Federal Government by virtue of its constitutional power to regulate commerce with foreign nations and among the several states; and partly through the police power inherent in the state (and often delegated in large measure to the city) to pass such laws and provide such regulations as are necessary to protect its citizens in their rights as to health, morals, and property.

Many communities had laws or ordinances for the prevention of milk adulteration long before making any attempt at general regulation of the entire food supply.

General food legislation was enacted and systematic inspection of food of all kinds was begun in Massachusetts about thirty years ago. Legislation of this character spread gradually, and in 1905 about half of the states had general food laws. The National law for prevention of adulteration or misbranding of foods or drugs was passed in 1906, and went in effect January 1, 1907. This stimulated further state legislation with the result that now nearly every state has a general food law and is making an attempt at its enforcement.

Thus the people, while no longer able to produce their own food or buy it of neighbors who have produced it under known conditions, may still through legislation seek to insure that the food they buy shall be:

- (1) What it purports to be, in kind and amount ;
- (2) Free from deterioration or unwholesome additions ;
- (3) Possessed of full nutritive value.

Most of our food laws take the form of prescribing what the food shall not be rather than what it shall be ; and these prohibitions are usually classified under the two heads of **adulteration** and **misbranding**.

Anything which makes a food unwholesome or lowers its nutritive value is usually considered *adulteration*; while to offer a food under false or misleading claims as to its source, kind, quality, or amount is usually called *misbranding*.

In view of the diversity of methods used in handling different kinds of foods, and the constant changing of methods to keep abreast of scientific developments and economic conditions, it is plain that there will often be room for difference of opinion as to whether or not a given trade practice shall be held to be adulteration or misbranding.

The attempt to settle such questions in advance by writing

detailed specifications into the law itself, may defeat its own purpose, since in general the more specific the wording of the law, the more literally (and hence narrowly) it must be construed. Thus in the Pennsylvania Food Act of May 13, 1909, the addition of alum to food is prohibited; but it was held by the courts that the word alum as used in the law means only potassium aluminum sulphate and not sodium aluminum sulphate nor simple sulphate of aluminum. The latter, being cheaper, are commonly used in the making of "alum" baking powders and for preserving the crispiness of pickles, and the introduction of aluminum into the food in these two ways is therefore allowed to continue, although it was for the express purpose of preventing this that the word alum was included in the list of forbidden substances in the law.

The Federal Food and Drugs Act of June 30, 1906, commonly known as "The Pure Food Law," and on which subsequent legislation by most of the states has been largely based, defines the main types of adulteration and misbranding, but, except in the case of confectionery and of habit-forming drugs, does not name the specific substances which are to be prohibited or restricted in use, nor does the law itself contain standards of composition for foods.

According to this law *a food is deemed adulterated* :

(1) If any substance has been mixed or packed with it so as to reduce or lower or injuriously affect its quality or strength.

(2) If any substance has been substituted, wholly or in part.

(3) If any valuable constituent has been wholly or in part abstracted.

(4) If it be mixed, colored, coated, powdered, or stained in a manner whereby damage or inferiority is concealed.

(5) If it contain any added poisonous or other added deleterious ingredient which may render it injurious to health.

(6) If it consists in whole or in part of a filthy, decomposed, or putrid animal or vegetable substance, or any portion of an

animal unfit for food, or if it be the product of a diseased animal, or one that has died otherwise than by slaughter.

And a food is deemed to be misbranded:

(1) If it be an imitation of or offered for sale under the distinctive name of another article.

(2) If it be labeled or branded so as to deceive or mislead the purchaser, or purport to be a foreign product when not so, or if the contents shall have been substituted in whole or in part, or if it fail to bear a statement on the label of the quantity or proportion of any narcotic or habit-forming drug which it contains.

(3) If, when sold in package form it fails to bear a correct statement of weight, measure, or numerical count of its contents; provision being made for reasonable variations and for certain exemptions.

(4) If the package containing it or its label shall bear any statement, design, or device which is false or misleading in any particular.

The exact wording of the definitions and the corresponding definitions of adulteration and misbranding as applied to confectionery and drugs may be seen by consulting the text of the law which is quoted in full below.

The Food and Drugs Act, June 30, 1906, as Amended August 23, 1912

AN ACT For preventing the manufacture, sale, or transportation of adulterated or misbranded or poisonous or deleterious foods, drugs, medicines, and liquors, and for regulating traffic therein, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be unlawful for any person to manufacture within any Territory or the District of Columbia any article of food or drug which is adulterated or misbranded, within the meaning of this Act; and any person who shall violate any of the provisions of this section shall be guilty of a misdemeanor, and for each offense shall, upon conviction thereof, be fined not to exceed five hundred dollars or shall be sentenced to one year's imprisonment, or both such fine and imprisonment, in the discretion of the court, and for each subsequent offense and conviction

thereof shall be fined not less than one thousand dollars or sentenced to one year's imprisonment, or both such fine and imprisonment, in the discretion of the court.

SEC. 2. That the introduction into any State or Territory or the District of Columbia from any other State or Territory or the District of Columbia, or from any foreign country, or shipment to any foreign country of any article of food or drugs which is adulterated or misbranded, within the meaning of this Act, is hereby prohibited; and any person who shall ship or deliver for shipment from any State or Territory or the District of Columbia to any other State or Territory or the District of Columbia, or to a foreign country, or who shall receive in any State or Territory or the District of Columbia from any other State or Territory or the District of Columbia, or foreign country, and having so received, shall deliver, in original unbroken packages, for pay or otherwise, or offer to deliver to any other person, any such article so adulterated or misbranded within the meaning of this Act, or any person who shall sell or offer for sale in the District of Columbia or the Territories of the United States any such adulterated or misbranded foods or drugs, or export or offer to export the same to any foreign country, shall be guilty of a misdemeanor, and for such offense be fined not exceeding two hundred dollars for the first offense, and upon conviction for each subsequent offense not exceeding three hundred dollars or be imprisoned not exceeding one year, or both, in the discretion of the court: *Provided*, That no article shall be deemed misbranded or adulterated within the provisions of this Act when intended for export to any foreign country and prepared or packed according to the specifications or directions of the foreign purchaser when no substance is used in the preparation or packing thereof in conflict with the laws of the foreign country to which said article is intended to be shipped; but if said article shall be in fact sold or offered for sale for domestic use or consumption, then this proviso shall not exempt said article from the operation of any of the other provisions of this Act.

SEC. 3. That the Secretary of the Treasury, the Secretary of Agriculture, and the Secretary of Commerce and Labor shall make uniform rules and regulations for carrying out the provisions of this Act, including the collection and examination of specimens of foods and drugs manufactured or offered for sale in the District of Columbia, or in any Territory of the United States, or which shall be offered for sale in unbroken packages in any State other than that in which they shall have been respectively manufactured or produced, or which shall be received from any foreign country, or intended for shipment to any foreign country, or which may be submitted for examination by the chief health, food, or drug officer of any State, Territory, or the District of Columbia, or at any domestic or foreign port through

which such product is offered for interstate commerce, or for export or import between the United States and any foreign port or country.

SEC. 4. That the examinations of specimens of foods and drugs shall be made in the Bureau of Chemistry of the Department of Agriculture, or under the direction and supervision of such Bureau, for the purpose of determining from such examinations whether such articles are adulterated or misbranded within the meaning of this Act; and if it shall appear from any such examination that any of such specimens is adulterated or misbranded within the meaning of this Act, the Secretary of Agriculture shall cause notice thereof to be given to the party from whom such sample was obtained. Any party so notified shall be given an opportunity to be heard, under such rules and regulations as may be prescribed as aforesaid, and if it appears that any of the provisions of this Act have been violated by such party, then the Secretary of Agriculture shall at once certify the facts to the proper United States district attorney, with a copy of the results of the analysis or the examination of such article duly authenticated by the analyst or officer making such examination, under the oath of such officer. After judgment of the court, notice shall be given by publication in such manner as may be prescribed by the rules and regulations aforesaid.

SEC. 5. That it shall be the duty of each district attorney to whom the Secretary of Agriculture shall report any violation of this Act, or to whom any health or food or drug officer or agent of any State, Territory, or the District of Columbia shall present satisfactory evidence of any such violation, to cause appropriate proceedings to be commenced and prosecuted in the proper courts of the United States, without delay, for the enforcement of the penalties as in such case herein provided.

SEC. 6. That the term "drug" as used in this Act, shall include all medicines and preparations recognized in the United States Pharmacopœia or National Formulary for internal or external use, and any substance or mixture of substances intended to be used for the cure, mitigation, or prevention of disease of either man or other animals. The term "food," as used herein, shall include all articles used for food, drink, confectionery, or condiment by man or other animals, whether simple, mixed, or compound.

SEC. 7. That for the purposes of this Act an article shall be deemed to be adulterated:

In case of drugs:

First. If, when a drug is sold under or by a name recognized in the United States Pharmacopœia or National Formulary, it differs from the standard of strength, quality, or purity, as determined by the test laid down in the United States Pharmacopœia or National Formulary official at the time of investigation: *Provided*, That no drug defined in the United States Pharma-

copœia or National Formulary shall be deemed to be adulterated under this provision if the standard of strength, quality, or purity be plainly stated upon the bottle, box, or other container thereof although the standard may differ from that determined by the test laid down in the United States Pharmacopœia or National Formulary.

Second. If its strength or purity fall below the professed standard or quality under which it is sold.

In the case of confectionery :

If it contain terra alba, barytes, talc, chrome yellow, or other mineral substance or poisonous color or flavor, or other ingredient deleterious or detrimental to health, or any vinous, malt, or spirituous liquor or compound or narcotic drug.

In the case of food :

First. If any substance has been mixed and packed with it so as to reduce or lower or injuriously affect its quality or strength.

Second. If any substance has been substituted wholly or in part for the article.

Third. If any valuable constituent of the article has been wholly or in part abstracted.

Fourth. If it be mixed, colored, powdered, coated, or stained in a manner whereby damage or inferiority is concealed.

Fifth. If it contain any added poisonous or other added deleterious ingredient which may render such article injurious to health: *Provided*, That when in the preparation of food products for shipment they are preserved by any external application applied in such manner that the preservative is necessarily removed mechanically, or by maceration in water, or otherwise, and directions for the removal of said preservative shall be printed on the covering or the package, the provisions of this Act shall be construed as applying only when said products are ready for consumption.

Sixth. If it consists in whole or in part of a filthy, decomposed, or putrid animal or vegetable substance, or any portion of an animal unfit for food, whether manufactured or not, or if it is the product of a diseased animal, or one that has died otherwise than by slaughter.

SEC. 8. That the term "misbranded," as used herein, shall apply to all drugs, or articles of food, or articles which enter into the composition of food, the package or label of which shall bear any statement, design, or device regarding such article, or the ingredients or substances contained therein which shall be false or misleading in any particular, and to any food or drug product which is falsely branded as to the State, Territory, or country in which it is manufactured or produced.

That for the purposes of this Act an article shall also be deemed to be misbranded :

In case of drugs :

First. If it be an imitation of or offered for sale under the name of another article.

Second. If the contents of the package as originally put up shall have been removed, in whole or in part, and other contents shall have been placed in such package, or if the package fail to bear a statement on the label of the quantity or proportion of any alcohol, morphine, opium, cocaine, heroin, alpha or beta eucaine, chloroform, cannabis indica, chloral hydrate, or acetanilide, or any derivative or preparation of any such substances contained therein.

Third. If its package or label shall bear or contain any statement, design, or device regarding the curative or therapeutic effect of such article or any of the ingredients or substances contained therein, which is false and fraudulent.

In the case of food :

First. If it be an imitation of or offered for sale under the distinctive name of another article.

Second. If it be labeled or branded so as to deceive or mislead the purchaser, or purport to be a foreign product when not so, or if the contents of the package as originally put up shall have been removed in whole or in part and other contents shall have been placed in such package, or if it fail to bear a statement on the label of the quantity or proportion of any morphine, opium, cocaine, heroin, alpha or beta eucaine, chloroform, cannabis indica, chloral hydrate, or acetanilide, or any derivative or preparation of any of such substances contained therein.

Third.¹ If in package form, the quantity of the contents be not plainly and conspicuously marked on the outside of the package in terms of weight, measure, or numerical count : *Provided, however,* That reasonable variations shall be permitted, and tolerances and also exemptions as to small packages shall be established by rules and regulations made in accordance with the provisions of section three of this Act.

Fourth. If the package containing it or its label shall bear any statement, design, or device regarding the ingredients or the substances contained therein, which statement, design, or device shall be false or misleading in any particular : *Provided,* That an article of food which does not contain any added poisonous or deleterious ingredients shall not be deemed to be adulterated or misbranded in the following cases :

¹ The act of March 3, 1913, provides that no penalty of fine, imprisonment, or confiscation shall be enforced for any violation of its provisions as to domestic products prepared or foreign products imported prior to eighteen months after its passage.

First. In the case of mixtures or compounds which may be now or from time to time hereafter known as articles of food, under their own distinctive names, and not an imitation of or offered for sale under the distinctive name of another article, if the name be accompanied on the same label or brand with a statement of the place where said article has been manufactured or produced.

Second. In the case of articles labeled, branded, or tagged so as to plainly indicate that they are compounds, imitations, or blends, and the word "compound," "imitation," or "blend," as the case may be, is plainly stated on the package in which it is offered for sale: *Provided*, That the term blend as used herein shall be construed to mean a mixture of like substances, not excluding harmless coloring or flavoring ingredients used for the purpose of coloring and flavoring only: *And provided further*, That nothing in this Act shall be construed as requiring or compelling proprietors or manufacturers of proprietary foods which contain no unwholesome added ingredient to disclose their trade formulas, except in so far as the provisions of this act may require to secure freedom from adulteration or misbranding.

SEC. 9. That no dealer shall be prosecuted under the provisions of this Act when he can establish a guaranty signed by the wholesaler, jobber, manufacturer, or other party residing in the United States, from whom he purchases such articles, to the effect that the same is not adulterated or misbranded within the meaning of this Act, designating it. Said guaranty, to afford protection, shall contain the name and address of the party or parties making the sale of such articles to such dealer, and in such case said party or parties shall be amenable to the prosecutions, fines and other penalties which would attach, in due course, to the dealer under the provisions of this Act.

SEC. 10. That any article of food, drug, or liquor that is adulterated or misbranded within the meaning of this Act, and is being transported from one State, Territory, District, or insular possession to another for sale, or, having been transported, remains unloaded, unsold, or in original unbroken packages, or if it be sold or offered for sale in the District of Columbia or the Territories, or insular possessions of the United States, or if it be imported from a foreign country for sale, or if it is intended for export to a foreign country, shall be liable to be proceeded against in any district court of the United States within the district where the same is found, and seized for confiscation by a process of libel for condemnation. And if such article is condemned as being adulterated or misbranded, or of a poisonous or deleterious character, within the meaning of this Act, the same shall be disposed of by destruction or sale, as the said court may direct, and the proceeds thereof, if sold, less the legal costs and charges, shall be paid into the Treasury

of the United States, but such goods shall not be sold in any jurisdiction contrary to the provisions of this Act or the laws of that jurisdiction: *Provided, however*, That upon the payment of the costs of such libel proceedings and the execution and delivery of a good and sufficient bond to the effect that such articles shall not be sold or otherwise disposed of contrary to the provisions of this Act, or the laws of any State, Territory, District, or insular possession, the court may by order direct that such articles be delivered to the owner thereof. The proceedings of such libel cases shall conform, as near as may be, to the proceedings in admiralty, except that either party may demand trial by jury of any issue of fact joined in any such case, and all such proceedings shall be at the suit of and in the name of the United States.

SEC. 11. The Secretary of the Treasury shall deliver to the Secretary of Agriculture, upon his request from time to time, samples of foods and drugs which are being imported into the United States or offered for import, giving notice thereof to the owner or consignee, who may appear before the Secretary of Agriculture, and have the right to introduce testimony, and if it appear from the examination of such samples that any article of food or drug offered to be imported into the United States is adulterated or misbranded within the meaning of this Act, or is otherwise dangerous to the health of the people of the United States, or is of a kind forbidden entry into, or forbidden to be sold or restricted in sale in the country in which it is made or from which it is exported, or is otherwise falsely labeled in any respect, the said article shall be refused admission, and the Secretary of the Treasury shall refuse delivery to the consignee and shall cause the destruction of any goods refused delivery which shall not be exported by the consignee within three months from the date of notice of such refusal under such regulations as the Secretary of the Treasury may prescribe: *Provided*, That the Secretary of the Treasury may deliver to the consignee such goods pending examination and decision in the matter on execution of a penal bond for the amount of the full invoice value of such goods, together with the duty thereon, and on refusal to return such goods for any cause to the custody of the Secretary of the Treasury, when demanded, for the purpose of excluding them from the country, or for any other purpose, said consignee shall forfeit the full amount of the bond: *And provided further*, That all charges for storage, cartage, and labor on goods which are refused admission or delivery shall be paid by the owner or consignee, and in default of such payment shall constitute a lien against any future importation made by such owner or consignee.

SEC. 12. That the term "Territory" as used in this Act shall include the insular possessions of the United States. The word "person" as used

in this Act shall be construed to import both the plural and the singular, as the case demands, and shall include corporations, companies, societies and associations. When construing and enforcing the provisions of this Act, the act, omission, or failure of any officer, agent, or other person acting for or employed by any corporation, company, society, or association, within the scope of his employment or office, shall in every case be also deemed to be the act, omission, or failure of such corporation, company, society, or association as well as that of the person.

SEC. 13. That this Act shall be in force and effect from and after the first day of January, nineteen hundred and seven.

Approved June 30, 1906.

Notes on the National Law and the Rules and Regulations for its Enforcement

Since in the chapters which follow there will frequently be occasion to refer to decisions which have been rendered or standards which have been established under the National law, it will be advantageous at this point to refer to some of its more prominent features and to the provisions for its interpretation and enforcement.

Scope and penalties. On account of the limitations placed by the Constitution upon Federal legislation of this sort, the law can *directly* prohibit the manufacture of adulterated or misbranded food only in the District of Columbia or the Territories. *Indirectly*, however, the manufacture of such food on a large scale anywhere in the country can be made difficult if not impracticable through the control of interstate and foreign commerce. Food manufactured and sold exclusively within the borders of any one state is subject only to state or municipal control, but any lot or package of food which passes from one state to another is subject to the provisions of the National law. Moreover, in all such interstate transactions in food products both the consignor and the consignee are liable unless one of them assumes complete liability under the provisions of Section 9. Often a shipment of food is seized and the prosecution

is brought against the goods, the interested parties being given opportunity to appear as claimants and answer the charge of adulteration or misbranding.

The first case under the law which was carried through the Supreme Court of the United States related to the powers of the Government under this section. Preserved eggs were shipped from St. Louis, Mo., to Peoria, Ill. They were intended not for sale (as such) but for use in baking and were placed in the storeroom of the bakery along with other supplies. The Government seized the eggs as adulterated food in interstate commerce; the egg company which had prepared them appeared as claimant and defended the suit but did not enter into a stipulation to pay costs. The case was tried in the United States District Court which found the eggs adulterated within the meaning of the act in that they contained about 2 per cent of boric acid which the court held to be a deleterious ingredient. The egg company contested the jurisdiction of the Court, claiming (1) that the law does not apply to an article which has been shipped not for sale but solely for use as a raw material in the manufacture of some other product, (2) that the United States District Court had no jurisdiction because the goods had passed out of interstate commerce and become mingled in the general mass of the property in the State of Illinois, and (3) that the Court had no jurisdiction to enter a personal judgment against the egg company for costs. The Supreme Court found the position of the egg company untenable on each of these points and stated in its decision upholding the Government that the adulterated eggs were illicit articles which could not acquire immunity by becoming a part of the general mass of property of the State and that the confiscation or destruction of such articles is the especial concern of the law.

By comparison of Sections 1 and 2, it will be seen that the penalties for interstate commerce in adulterated or misbranded foods are somewhat less severe than for the manufacture of such food in those parts of the country which are under the direct jurisdiction of the Federal Government.

Rules and regulations. Section 3 of the law makes it the duty of the Secretary of the Treasury, the Secretary of Agriculture, and the Secretary of Commerce to formulate uniform rules and regulations for the carrying out of the provisions of the law. As already mentioned, most of the provisions and definitions in

the law are general in character. It therefore became necessary for the three Secretaries in the Rules and Regulations, not only to provide a plan for the collection and examination of samples, but also to interpret many of the definitions of adulteration and misbranding.

The Rules and Regulations adopted by the Secretaries are given in full at the back of this book (Appendix A).

These rules and regulations are of course subject to review by the Courts and they do not have the force and effect of law except in so far as they interpret the law correctly. They are, however, of great importance as constituting the working basis for the enforcement of the law and will be frequently referred to in the discussions which follow.

Food inspection decisions. The actual administration of the law and of the rules and regulations is the duty of the Secretary of Agriculture. Notwithstanding the adoption of the Rules and Regulations, several questions of interpretation requiring decision by the administrative officers have arisen.

These decisions are published from the Office of the Secretary, United States Department of Agriculture, in a series of numbered leaflets called Food Inspection Decisions (F. I. D.).

A few of these decisions have been signed by the three Secretaries and are practically amendments of the Rules and Regulations. In most cases, however, the "decisions" are simply declarations of the attitude of the Department of Agriculture and are signed either by the Secretary of Agriculture or by the Board of Food and Drug Inspection, which is a committee appointed by the Secretary from among the officials of the Department of Agriculture and who act as the representatives of the Secretary in the enforcement of the food law. These decisions of the administrative officers must not be confused with the decisions reached by the courts. The latter are found under Notices of Judgment (see below).

Many of the Food Inspection Decisions will be quoted in

later chapters in the discussion of the particular types of food to which they relate. Those of more general scope will be found at the back of this book (Appendix B).

Collection of samples. Samples are collected only by authorized agents of the Department of Agriculture or by some health, food, or drug officer commissioned by the Secretary of Agriculture for this purpose. The collectors must purchase representative samples. Samples purchased in bulk are divided into three parts; when in the original unbroken packages three such packages are usually taken. One of the three samples is delivered to the chemist or examiner and two are held under seal by the Secretary of Agriculture, "who, upon request, shall deliver one of such samples to the party from whom purchased or to the party guaranteeing such merchandise." (Regulation 3.)

The term "original unbroken package" as used in the law is defined, in the Rules and Regulations, as "the original package, carton, case, can, box, barrel, bottle, phial, or other receptacle put up by the manufacturer, to which the label is attached, or which may be suitable for the attachment of the label" and it is held that the original package contemplated includes both the wholesale and the retail package.

Examinations or analyses of samples are made in the laboratories of the Bureau of Chemistry of the Department of Agriculture or under its direction and supervision. Unless otherwise directed by the Secretary of Agriculture, foods are analyzed by the methods of the Association of Official Agricultural Chemists, and drugs by the methods of the United States Pharmacopœia.

Standards of purity. The Pharmacopœia gives standards of purity for drugs along with the methods of analysis. The methods of analysis of the Association of Official Agricultural Chemists do not provide corresponding standards, but a set of standards drawn up by a committee of this Association was published as Circular No. 19, Office of the Secretary, United

States Department of Agriculture, and these are usually, though not necessarily, followed in interpreting the analytical results. The food chemists of the different states are also apt to govern their decisions by these standards unless some other standard is provided for by state law.

These standards, therefore, carry considerable weight and will be considered in connection with the discussions of the composition of food materials in the chapters which follow. They are variously designated as "United States Standards," "Government Standards," "Federal Standards," "Department of Agriculture Standards," or "A. O. A. C. Standards." The latter term is the more accurate since these standards for foods, while often cited in Federal prosecutions, are not established by law nor referred to in the Rules and Regulations, but represent the action only of the Association of Official Agricultural Chemists (A. O. A. C.). In connection with the Federal law and the laws of many states the force of these standards is practically that of expert testimony. In some states these or similar standards have been written into the law itself and it has been proposed that the Federal law be amended to include such standards.

Hearings (Regulation 5). When the examination or analysis indicates that a sample is adulterated or misbranded within the meaning of the law, notice is given to the party or parties responsible for the food and opportunity is given for a hearing before the Secretary of Agriculture or his representative. These hearings are confined to questions of fact (as distinguished from questions of law). The interested parties may appear in person or by attorney and may submit evidence to show any fault or error in the findings of the analyst or examiner and may present questions to be propounded to analysts by the officer conducting the hearing. The Secretary of Agriculture may order a reexamination of the sample or have new samples drawn for examination.

Prosecutions. If, after a hearing, it appears that a violation

of the law has been committed, the Secretary of Agriculture reports the case to the Department of Justice for prosecution, and action is brought by the proper United States attorney, the cases being tried in the Federal courts.

Notices of judgment. Not less than thirty days after a judgment of the court shall have been rendered, the findings are published in such form as the Secretary of Agriculture may direct. Usually the result of each trial is published under a separate number and distributed in leaflet form, each leaflet containing one or more notices. These notices are numbered in series and designated as Notices of Judgment (N. J.). Up to the beginning of 1914, when the law had been seven years in effect, there had been issued from the Office of the Secretary of Agriculture 2762 such Notices of Judgment.¹ Of these cases more than nine tenths had been decided favorably to the Government. If an appeal is taken from the judgment of the court before the publication of the Notice of Judgment, notice of the appeal must accompany the publication.

Definitions of adulteration and misbranding. The types of adulteration and misbranding recognized by the law were summarized above and their exact wording may also be seen from the text of the law. Some types of adulteration and misbranding can be demonstrated directly, while others are detected through the fact that analysis shows the article to be of inferior composition. The latter cases require the acceptance of some standard for comparison. For this purpose the standards of the Association of Official Agricultural Chemists already referred to, have generally been upheld by the courts. Some of the Rules and Regulations and many of the Food Inspection Decisions are also in the nature of interpretations of the definitions of adulteration and misbranding.

The clause which declares a food adulterated if it contain any added poisonous or other added deleterious ingredient which

¹ In April, 1914, the number had reached 3096.

may render such article injurious to health, has given rise to more discussion than any other part of the law. It had become a custom of the trade to use in the preparation of food a number of substances which had been found helpful in securing the desired color or keeping qualities of the foods, but whose wholesomeness had sometimes been questioned.

Congress declined to include in the food law any specific authorization or prohibition of any particular substance so used, leaving this to be covered by the rules and regulations which the three Secretaries were directed to prepare, and appropriating money to the Department of Agriculture for investigations as to the wholesomeness of these substances.

The three Secretaries then provided (Regulation 15b) that: "The Secretary of Agriculture shall determine from time to time, in accordance with the authority conferred by the agricultural appropriation act, Public 382, approved June 30, 1906, the principles which shall guide the use of colors, preservatives, and other substances added to foods; and when concurred in by the Secretary of the Treasury and the Secretary of Commerce, the principles so established shall become a part of these regulations."

Regarding the wholesomeness of colors, it is the practice to permit the use of any natural vegetable or animal color which is not known to be impure or injurious, but to be much more stringent with respect to the use of artificial (synthetic) colors. Only seven artificial colors have so far been authorized and of these the purity of each batch must be attested before it can legally be used. (See Appendix.)

Whether the presence of an authorized color must be declared upon the label will depend upon the nature of the food and will be considered in studying the different types of food in the chapters which follow. Any coloring which is intended to mislead is illegal and in most other cases the fact that the food has been artificially colored must be plainly stated.

Under these regulations many manufacturers who formerly used artificial coloring have ceased to do so. Thus one of the good effects of the law is that it results in foods being marketed in more nearly their normal appearance.

The establishment of principles to guide the use of preservatives has presented greater difficulty than in the case of colors, partly for the obvious reason that the preservation of food is necessary while the coloring of food is not. It is true that by drying, by heating and canning, and to a certain extent by refrigeration, foods may be preserved from the season of abundance to the season of scarcity without the addition of any preservative substance, but such a restriction of method of preservation would often be unnecessarily burdensome and costly and would in many cases involve a loss of the flavor for which the food is chiefly prized. The prohibition of all preservative substances would be as unsatisfactory to the consumer as to the producer and has never been seriously contemplated. What has sometimes been attempted is to divide all preservative substances into two classes, those in one class to be freely permitted and those in the other class to be strictly forbidden. The fact that the law defines food in such a way as to include condiments has been construed as tacitly authorizing the unlimited use of such preservatives as have condimental properties (like salt, sugar, vinegar, and woodsmoke) and the question of wholesomeness has as yet been officially raised only with respect to the noncondimental preservatives such as saltpeter, sodium benzoate, salicylic acid, and sulphur dioxide.

To assist the Secretary of Agriculture in determining the wholesomeness of certain of the preservative substances used, a Referee Board of Consulting Scientific Experts consisting of five prominent scientists, not otherwise connected with the Government service, has been appointed. In general such Rules and Regulations governing the use of preservatives as have been formulated by the three Secretaries have been based on the find-

ings of the Referee Board or have been made tentatively pending investigation. The regulations at present in force are given in full in Appendix B. As might be anticipated, when the different (noncondimental) preservative substances are treated each on its own merits the regulations deemed necessary are not the same in all cases. Regarding the four substances just mentioned the present Federal regulations are as follows: Saltpeter may be used without restriction; sodium benzoate may be used with no restriction except that the presence and true amount must be stated on the label; salicylic acid is forbidden; sulphur dioxide may be used only in those foods in which its use was already common and only in strictly limited amounts.

Guaranty. In order to secure justice in the fixing of responsibility, the law provides (Section 9) that the manufacturer or wholesaler may assume responsibility for his products so that he and not the retail dealer shall be held responsible in case of adulteration or misbranding. Formerly this was done by filing a general guaranty which was recorded under a Serial Number. Each package then bore a label showing the serial number and name and address of the party responsible for the guaranty. This guaranty was simply to fix responsibility and to protect the retail dealer. It afforded no additional protection to the consumer and added nothing to the penalty in case the food was found to be adulterated or misbranded. This, however, was not always understood, many purchasers supposing that they derived some additional protection from such guaranty.

Notice has now been given of an amendment to Regulation 9, relating to guaranty, which amendment, effective May 1, 1916, abolishes the issuing of serial numbers and forbids their use or the printing of the "guaranty legend" on the labels.

Under the new regulation the guaranty should be incorporated in or attached to the bill of sale, invoice, bill of lading, etc., and should not appear on the labels or packages.

Imported foods. Section 14 of the law provides for the inspection of foods while still in the hands of the customs officers or under bond. This greatly facilitates the prevention of importation of adulterated food, and it is believed that comparatively little adulterated food is now imported. When adulterated food bearing labels indicating a foreign origin is found in the American market the possibility of fraudulent labeling is also to be considered. Note that, as an additional precaution in the case of imported foods, the law forbids the importation of any kind of food which is forbidden entry to, or forbidden to be sold or restricted in sale in, the country in which it is made or from which it is exported.

Private importations. In Food Inspection Decision 88 it is held that no food or drug which is adulterated or misbranded within the meaning of the act shall be brought into the United States from abroad even if only for the consumption of the importer or for free distribution. Such private importations are subject to the same rules and restrictions as ordinary commercial imports.

State and Municipal Food Control

Since the Federal authorities cannot inspect or control any food which is produced and consumed in the same state, it is evident that each of the forty-eight states must have adequate legislation and inspection if its citizens are to obtain the full benefit of the pure food movement. In order fully to realize the importance of state and municipal control, one must remember that some of the foods most readily subjected to fraudulent adulteration (*e.g.* milk) and some of those most subject to dangerous contamination (*e.g.* meats and shellfish) are largely handled by producers and dealers who do a local business and so do not come under the authority of the Federal government. Slaughtering and meat packing is now a highly centralized industry and is regulated both by the Food and Drugs Act and by a special Meat Inspection Law (see Chapter VI and Appendix D), yet about half the meat consumed in the United States is slaughtered in local establishments which are never visited by the Federal inspectors because they do no interstate business.

The rural population and the residents of small towns, who together make up about one half the people of the United

States, derive relatively little *direct* benefit from the Federal law. *Indirectly* they benefit in proportion as the Federal legislation and inspection serves to stimulate and standardize that of the states. At the present time most of the states have on their statute books food laws which are modeled more or less directly after the Federal law and which are fairly satisfactory in so far as they are enforced. Rarely, however, are sufficient funds appropriated to make possible a strict enforcement of the state law.

On the other hand, state laws may be more stringent in some respects than those of the Federal government. Thus several states limit the time that food may be held in cold storage. The new (1914) Sanitary Code of New York State makes it unlawful for any person "affected with any communicable disease to handle food or food products in any manner whatever."

The responsibility of the enforcement of state food laws is lodged sometimes with health officers, sometimes with the commissioner of agriculture, sometimes with a food commissioner independent of either the department of agriculture or of health. Not infrequently the office of "dairy and food commissioner" has developed through the fact that legal regulation of the milk supply and dairy industry antedated general food legislation. Whatever the organization, it is important that the enforcement of the state food laws be in the hands of permanent officials, scientifically trained, gifted with good judgment and administrative capacity, and entirely independent of politics.

State legislation and inspection may be supplemented by municipal ordinances enforced by distinct corps of officers. In New York City, for example, the board of health has the power to enact a sanitary code which becomes law on publication without requiring the approval of any other body or official. This code contains general rules for food control, and additional rules and regulations to govern certain industries are also promul-

gated by the board and thus become part of, and have the legal force of, the code. The board of health has the power to control any food industry by requiring that it be carried on only under permits granted by (and revokable by) the board. Violations of the sanitary code may be punished either by criminal prosecution or civil suit. The policy has been to bring criminal prosecution in all cases of actual adulteration. In 1913 there were 118 inspectors connected with the New York City division of food inspection, of whom 41 were assigned to general food inspection, 19 to country milk inspection, 29 to city milk inspection, and 18 were sanitary inspectors engaged in the supervision of physical conditions in establishments where food is prepared or sold; there were also 4 medical inspectors and 7 veterinarians. For the laboratory examination of food the city employed 8 chemists with 7 technical and clerical assistants and 4 bacteriologists with 10 assistants. Furthermore, the city requires that the following food industries be carried on only under official permits and specific regulations: dealers in milk and all places where milk is sold; slaughterhouses, including poultry-killing establishments; sausage factories; egg-breaking establishments; establishments for the bottling of "soft drinks"; or for the manufacture of ice cream and other frozen products.

In all probability the next few years will see a marked development of state and municipal food control along lines consistent with the Federal food inspection, but in some cases even more exacting, as, for example, in requiring the grading and classification of market milk and not simply that it be free from adulteration or misbranding.

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CHAPTER III

MILK

MILK is the one article of diet whose sole function in nature is to serve as food. Each species of mammal produces a milk especially adapted to the nutritive requirements of its own young, but it was early learned that the milk of other species is also an excellent food for man, and several different species are used for dairy purposes in various parts of the world. In general only cows' milk is of much commercial importance, and the statements which follow refer always to cows' milk unless otherwise explained.

The amount of milk consumed as such ¹ in the United States is estimated at one half pint to one third of a quart per person per day. This amounts to some 25,000,000 to 30,000,000 quarts per day for the country as a whole. If the average retail value is about 5 cents a quart, the milk industry of the country will be seen to amount to over \$1,250,000 a day or over \$400,000,000 per year.

The importance of the milk industry to the community is much greater than its money value (as compared with other industries) would imply. It is probable that the quality of the milk supply bears a closer relation to the public health than does that of any other food. This is partly because of the exceptional nutritive qualities of milk and the prominent part which it plays in the diet of children and others to whom the quality of the food is of special importance, and partly because the

¹ A much larger quantity is used for the manufacture of butter and cheese. These industries will be described later.

fluidity and opacity of milk offer unusual opportunity for adulteration; and the fact that bacteria readily grow and multiply in it makes it especially important that the milk be carefully guarded from contamination.

It is therefore important that the milk industry be controlled with all possible care and with reference both to the nutritive and to the sanitary qualities of the product.

In the present chapter the production and handling of milk will first be outlined, then its composition and standards of purity will be discussed, and finally its nutritive value, pecuniary economy, and place in the diet will be considered.

Production and Handling of Milk

The cows. A milch cow should produce an average of over 2 gallons of milk per day for eight months of each year with a smaller yield for about two months longer, making a total of at least 600 gallons or at least 5000 pounds of milk for the year.

Many high-grade cows produce three or four times this quantity, and Wing cites the case of one cow which produced over 30,000 pounds of milk in a year; but the average for all the milch cows in the United States at the present time would doubtless be below the 5000 pounds suggested.

Increased yield of milk per cow may be obtained both by breeding and selection and by superior care and feeding. According to a recent estimate the annual yield of milk per cow in Denmark, where the dairy industry is well developed and highly systematized, has increased from 4480 pounds in 1898 to 4884 pounds in 1901, 5335 pounds in 1904, and 5874 pounds in 1908.

Since the fat of the milk is commercially its most valuable constituent, the productiveness of a milch cow is perhaps as often expressed in terms of fat or butter yield as in terms of weight of milk. Those races of cattle which have been developed with special reference to milk or butter production are called the dairy breeds, and those which are chiefly useful for

meat production are known as beef breeds. A recent investigation in Wisconsin¹ showed a higher food consumption on the part of the more productive dairy cows, but the value of the milk produced increased much more rapidly than the cost of feed so that the more productive cows proved very much more profitable.

Good health of the cow is of great importance and should be insured by semiannual veterinary inspection. Annual or semiannual testing with tuberculin with elimination or segregation of all cows which give evidence of tuberculosis serves to protect the herd from the ravages of the disease as well as to remove one source of possible danger to the consumer of the milk. When new cows are to be added to a dairy herd, care should be taken to ascertain that they are free from disease, particularly tuberculosis.

Dirt and dust adhering to the cow constitute one of the most serious sources of contamination of milk. It is therefore very important that the cows be kept clean and especially that the udder and adjacent parts of the body be thoroughly clean at the time of milking.

The stable should be free from contaminating surroundings, well drained, well lighted and ventilated, as clean and comfortable as possible. It should be used for no other purpose than the keeping of cows, and if there is a loft overhead the ceiling should be tight to prevent the falling of dust. The feeding of the cows should be so planned that there will be no dust from hay or other feed in the air of the stable at milking time. The floor should be tight, constructed preferably of cement and properly guttered; walls and ceilings should be whitewashed twice a year.

The milk house should be separate from the stable and so located as to be free from dust and odors. It should be used for no other purpose and should be light, clean, and well screened.

¹ Studies in Dairy Production, based on the Records secured in the Wisconsin Dairy Cow Competition, 1909-1911. Wisconsin Agricultural Experiment Station, Research Bulletin 26 (October, 1912).

All utensils which come in contact with the milk should be of metal with smoothly soldered joints. In addition to being thoroughly washed the utensils should be sterilized by means of steam or boiling water and then kept either closed or inverted in a clean place free from dust until used. By furnishing the farmers with sterilized utensils for each milking and insisting upon the use of covered milking pails (see below) Dr. North effected an enormous reduction in the bacterial contamination of milk.

Milking is performed sometimes by machine, but usually by hand. Cleanliness of the milker and his clothing are essential to cleanliness of the milk. On well-conducted milk farms the milker puts on a special washable suit for milking and washes and dries his hands immediately before commencing to milk each cow. The cows having previously been cleaned, the udders and flanks should be wiped with a moist cloth preparatory to milking. As a further precaution against the falling of dust and bacteria into the milk a covered or hooded milking pail should be used.

Machines by means of which one man may milk several cows at a time are now on the market. These have the advantage of reducing the number of employees required in milking and diminishing the opportunities for contamination of the milk through contact with the air of the stable or the hands of the milker; among the disadvantages are the cost of the equipment necessary for machine milking and the difficulty of preventing the rubber parts of the mechanism from becoming a breeding place for bacteria. A recent extended study at the New York State Agricultural Experiment Station¹ led to the conclusion that machine milk now compares favorably with ordinary hand milking in its effect upon the milk flow and upon the germ content of the milk; that machine milking has proven practicable and is of interest mainly because of the labor problem.

¹ Bulletin No. 353, November, 1912.

Handling the milk. The milk is removed from the stable to the milk room as quickly as possible and (after clarifying or straining through sterile cotton or cloth if deemed necessary) is promptly cooled to prevent the growth and multiplication of such bacteria as it may contain.¹ The importance of early and thorough cooling was well shown in an experiment by Conn, in which it was found that the multiplication of bacteria in 24 hours in milk kept at 50° F. (10° C.) was only fivefold, while at 70° F. (21° C.) it was seven hundred and fifty fold.

Usually the milk is first poured into a mixing tank, then run over a metal cooler, and the cold milk filled into cans or bottles and kept cold both in storage and during transportation. In many localities it is required by law that milk be held at a temperature not above 50° or 55° F. until delivered to the consumer. Preferably the milk is bottled in the country, the bottles packed in cracked ice and kept so until delivered to the consumer.

General sanitation. In recent years much attention has been given to improvements in the sanitary conditions surrounding the production and handling of milk, largely because it is realized that contaminated milk may undergo such deterioration as to become unwholesome, or may be the means of transmitting specific infectious diseases. As an aid to dairy farmers the Dairy Division of the United States Department of Agriculture has published for free distribution *Twenty Dairy Suggestions with Special Reference to Sanitation*, which are printed on cloth in poster form suitable for posting in barns and milk rooms. The rules for the production and handling of certified milk, which may be taken as representing ideal conditions, are given in full at the back of this book. (See Appendix C.)

As an example of the influence of sanitary precautions upon the keeping qualities of milk, it may be noted that three Ameri-

¹ The multiplication of bacteria in milk does not begin as soon as the milk is drawn, but is preceded by a short period in which there is an apparent decrease in the number of bacteria. This is attributed to a "bactericidal property" of freshly drawn milk.

can dairy farms exhibited raw milk at the Paris Exposition of 1900, one of them sending weekly shipments throughout the summer, each of which was kept on exhibition in the raw state without spoilage until the next shipment arrived. It was difficult to convince the jury of European experts of the fact that "cleanliness and cold" were the only preservatives needed to accomplish the keeping of raw milk in a fresh sweet condition for two to four weeks in midsummer.

In order to provide definite standards for judging and recording sanitary conditions, **dairy score cards** have been formulated and are widely used. The one published by the Bureau of Animal Industry, United States Department of Agriculture,¹ is given on pages 54 and 55.

The ratings obtained by dairies under the score card system of inspection are often employed as one means of classifying milks with regard to their degrees of excellence. Usually the sanitary quality of the milk as judged by laboratory methods runs approximately parallel with the sanitary care exercised in its production and handling, but there are sometimes discrepancies; and at present there is difference of opinion among sanitarians as to the relative weight which should be given (1) to the dairy score, (2) to the results of laboratory examinations, for the purpose of fixing the sanitary quality of the milk offered for sale.

In this connection the following statement recently authorized by the United States Department of Agriculture is of interest:

Information has come to the Department of Agriculture that persons, representing certain milk dealers, are circulating the statement that the United States Department of Agriculture has abandoned all bacteriological examination of milk as a test for its cleanliness and fitness for human consumption.

The Department, therefore, has issued the following statement of its position.

¹ Twenty-sixth Annual Report of the Bureau of Animal Industry, p. 120.

DAIRY SCORE CARD

Score for equipment _____ + Score for methods _____ = _____ Final score

EQUIPMENT	SCORE		METHODS	SCORE	
	Perfect	Allowed		Perfect	Allowed
COWS			COWS		
Health	6	.....	Cleanliness of cows . .	8	.....
Apparently in good health I			STABLES		
If tested with tuberculin once a year and no tuberculosis is found, or if tested once in six months and all reacting animals removed . . 5			Cleanliness of stables	6	.....
(If tested only once a year and reacting animals found and removed, 2.)			Floor 2		
Comfort	2	.....	Walls I		
Bedding I			Ceiling and ledges . I		
Temperature of stable I			Mangers and partitions I		
Food (clean and wholesome)	2	.....	Window I		
Water	2	.....	Stable air at milking time	6	.....
Clean and fresh . . . I			Barnyard clean and well drained	2	.....
Convenient and abundant I			Removal of manure daily to field or proper pit	2	.....
STABLES			(To 50 feet from stable, 1.)		
Location of stable . .	2	.....	MILK ROOM		
Well drained I			Cleanliness of milk room	3	.....
Free from contaminating surroundings . . I			UTENSILS AND MILKING		
Construction of stable . .	4	.....	Care and cleanliness of utensils	8	.....
Tight, sound floor and proper gutter . . 2			Thoroughly washed and sterilized in live steam for 30 minutes . . 5		
Smooth, tight walls and ceiling . . . I			(Thoroughly washed and placed over steam jet, 4; thoroughly washed and scalded with boiling water, 3; thoroughly washed, not scalded, 2.)		
Proper stall, tie, and manger I			Inverted in pure air . 3		
Light: Four sq. ft. of glass per cow . . .	4	.....	Cleanliness of milking .	9	.....
(Three sq. ft., 3; 2 sq. ft., 2; 1 sq. ft., 1. Deduct for uneven distribution.)			Clean, dry hands . 3		
Ventilation: Automatic system	3	.....	Udders washed and dried 6		
(Adjustable window, 1.)			(Udders cleaned with moist cloth, 4; cleaned with dry cloth at least 15 minutes before milking, 1.)		
Cubic feet of space for cow: 500 to 1000 feet (Less than 500 feet, 2; less than 400 feet, 1; less than 300 feet, 0; over 1000 feet, 0.)	3	.....			

DAIRY SCORE CARD—Continued

Score for equipment..... + Score for methods..... = Final score

EQUIPMENT	SCORE		METHODS	SCORE	
	Perfect	Allowed		Perfect	Allowed
UTENSILS			HANDLING THE MILK		
Construction and condition of utensils . .	1		Cleanliness of attendants	1	.....
Water for cleaning . .	1	.....	Milk removed immediately from stable	2	.....
(Clean, convenient and abundant.)		.....	Prompt cooling (cooled immediately after milking each cow)	2	.....
Small-top milking pail .	3	.....	Efficient cooling; below 50° F.	5	.....
Facilities for hot water or steam	1	.....	(51° to 55°, 4; 56° to 60°, 2.)		
(Should be in milk house, not in kitchen.)			Storage; below 50° F. .	3	.....
Milk cooler	1	.....	(51° to 55°, 2; 56° to 60°, 1.)		
Clean milking suits . .	1	.....	Transportation; iced in summer	3	.....
MILK ROOM			(For jacket or wet blanket allow 2; dry blanket or covered wagon, 1.)		
Location of milk room .	2	.....			
Free from contaminating surroundings .	1				
Convenient	1				
Construction of milk room	2	.....			
Floor, walls, and ceiling	1				
Light, ventilation screens	1				
Total	40	.....	Total	60	.....

1. All statements that the Department has abandoned, or will abandon, the bacteriological examination of milk shipped in interstate commerce as a means of determining its cleanliness and fitness for human consumption are without foundation. While the Department has not fixed any specific bacteriological count as a standard in the enforcement of the Food and Drugs Act, it does use bacteriological examinations in reaching its conclusions, and will continue to use these methods irrespective of what action any Association may take. The Department has never stated that it will not use such methods.

2. The only change in policy in the Department in regard to bacteriological examinations has been to discontinue basing prosecution upon the bacteriological examination of a single sample. It now collects a number of samples at different times and examines them bacteriologically. If the bac-

teriological examination shows that the milk is not clean, but is not a serious menace to health, and the bacteriological deviation from clean milk is a small one, the Department, through the Bureau of Animal Industry, endeavors to teach the dairyman how to produce clean milk. If he then neglects to take measures to make his milk clean and safe for human consumption, the Department, by taking action in the case of milk shipped in interstate commerce, endeavors to force him to bring his milk to a point of safety and food excellence through prosecutions under the Food and Drugs Act.

Certified milk. This term is properly applied only to milk produced under sanitary conditions of exceptional excellence, by the most painstaking methods and under the constant supervision and inspection of a Medical Milk Commission. It is understood as meaning that the milk is certified as to its quality and wholesomeness by a properly constituted medical milk commission. The medical profession was led to engage in the certification of milk in order that there might be made available for infant feeding at least a limited supply of milk of exceptional excellence which should be as nearly as possible absolutely safe. The requirements placed upon the producer and handler are such as to make the cost of certified milk about twice that of ordinarily good bottled milk. Although less than 1 per cent of the market milk of commerce is of this grade, the certified milk movement has had great influence in improving dairy practice and raising the sanitary quality of the general milk supply. The detailed requirements for the production and handling of certified milk are given in Appendix C at the back of this book.

The North system of sanitary milk production differs from the system in which certified milk is produced in that much of the responsibility which the certified milk system imposes upon the farmer is by the North system transferred to the receiving station. The farmer must keep only healthy cows and must clean them before milking, and the milk must be drawn by a clean milker into covered pails, transferred without straining

to the milk cans and kept in icewater until sent to the receiving station. At the receiving station all pails and cans are thoroughly washed, sterilized with live steam, dried with a blast of hot air, covered and delivered back to the farmer who must keep them unopened until the next milking time. Other features of the North system are daily laboratory tests of each farmer's milk at the receiving station and payment according to the quality of the milk as shown by these tests.

Pasteurization of milk by heating it to a temperature of 60° to 63° C. (140° to 145° F.) and holding at this temperature for 20 to 30 minutes serves to destroy any bacteria of diseases regarded as transmissible by milk. The use of higher temperatures in order to shorten the time required for pasteurization is often permitted, but is undesirable ; partly because of the possibility that higher temperature may cause chemical changes in certain of the substances in the milk ; partly because higher heating kills an undue proportion of the lactic acid bacteria while the spores of certain bacteria which decompose the proteins of the milk are not destroyed and, if the milk be kept too long, may render it unwholesome before it becomes sour. As a precaution against subsequent contamination it is desirable that the milk be pasteurized in the sealed bottles in which it is to be delivered to the consumer. This can be done commercially at little cost on a large scale by means of apparatus already on the market for the pasteurization of bottled beer. There is a growing tendency on the part of public health authorities to require the pasteurization of all market milk which is not obtained under good sanitary conditions from tuberculin-tested cows.

General Composition of Milk

The qualitative composition has been concisely stated by Richmond as follows: " It is essentially an aqueous solution of milk-sugar, albumin, and certain salts, holding in suspension

globules of fat, and in a state of semi-solution, casein¹ together with mineral matter. Small quantities of other substances are also found." Under the microscope the fat globules are readily seen floating in the fluid portion or serum of the milk. (See Fig. 2.) These globules vary considerably in size from an

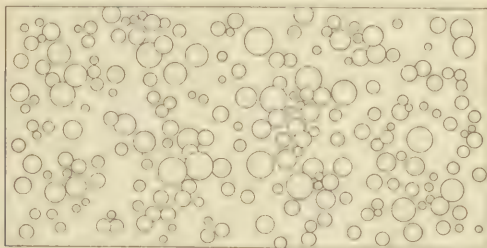


FIG. 2. — Fat globules in milk magnified 300 diameters.

average of about 0.0025 millimeter or 0.0001 inch in diameter. A single drop of milk contains many millions of these fat globules.

The yellowish tint of milk is due to a small quantity of coloring matter contained in the fat, and its opacity in part to the fat and in part to other constituents, particularly the caseinogen and the calcium phosphate. The reaction of fresh cows' milk is practically neutral to litmus and slightly acid to phenolphthalein, due chiefly to the presence of phosphates and carbonic acid.

Colostrum, the fluid secreted from the mammary glands for a short time after giving birth to the young, is different in composition and physiological properties. Under the microscope colostrum shows characteristic corpuscles in addition to the fat globules seen in milk.

The quantitative composition of milk varies with a number of conditions the most prominent of which are the breed and the

¹ For this protein as it exists in milk the term "caseinogen" is perhaps preferable, the term "casein" being more strictly applicable to the coagulated protein as it exists in curd or cheese.

individual characteristics of the cow. It is difficult to make fair comparisons of breeds because there may be within the same breed different strains or families which differ markedly in the composition of their milk. The following figures obtained by averaging the results of independent breed tests made at the Agricultural Experiment Stations of New York and New Jersey are believed to be fairly representative:

TABLE 1. COMPOSITION OF MILK OF DIFFERENT BREEDS OF CATTLE

BREED	TOTAL SOLIDS	FAT	SOLIDS-NOT-FAT
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Jersey	14.87	5.19	9.68
Guernsey	14.69	5.16	9.53
Durham	13.38	4.05	9.33
Ayrshire	12.73	3.64	9.09
Holstein	11.96	3.43	8.53

Among the conditions other than breed and individuality which may influence the composition of cows' milk may be mentioned advancement in lactation, the season of the year, feeding and care, time and completeness of milking.

After a cow has been three or four months in lactation there is usually a decrease in the milk and a gradual increase in the richness of the milk as the period of lactation advances. At the end of the lactation period when the cow is "going dry" there is sometimes a marked increase in the richness of the milk, but the quantity produced at such times is usually too small to exert much influence on the average composition of the mixed milk of the herd.

Other conditions being the same, the milk of well-kept cows is usually richer in winter than in summer, in cooler than in warmer weather, and on rich dry food than on pasture, except that on first admitting the cows to pasture in spring or early summer a richer milk may be obtained for a short time. The

milk of late autumn or early winter usually averages from 0.25 to 0.50 per cent higher in fat and also in protein than the milk of midsummer.

Doubtless reasonably good feeding and care are necessary to secure from each cow as rich a milk as she is normally capable of producing, and there are indications that by changes of food, liberal feeding with special foods or perhaps other special treatment, a cow may be made to produce for a time a milk above her normal standard of richness. In general practice, however, the dairy farmer depends upon breeding and selection to secure milk of high richness and expects the return for liberal feeding and exceptional care to take the form of an increased yield of milk rather than a permanent change in its composition.

In general a longer interval of time between milkings results in a slightly decreased fat content. This is often the cause of a fairly constant difference of 0.25 to 0.50 per cent of fat in the morning and afternoon milk of the same herd.

All statements regarding the composition of cows' milk ordinarily refer to the product of complete milking. In partial or fractional milking the first portions drawn are much poorer in fat content than the average, and the last portions, or "strip-pings," are much richer.

The extreme variations in composition of milk from cows apparently normal have been compiled by the writer elsewhere.¹ Since market milk is nearly always the mixed product of many cows and often of many herds, a knowledge of these extremes is for practical purposes much less significant than is a knowledge of the usual variations. The following table includes a statement of (1) the variations which may be considered not unusual, (2) an estimate of average composition based on all available data, (3) a convenient approximation to the estimate average which is sufficiently accurate for most purposes and is generally used in estimates of the food value of milk.

¹ *Methods of Organic Analysis*, Revised Edition, page 351.

TABLE 2. COMPOSITION OF MILK; USUAL LIMITS AND AVERAGE

CONSTITUENT	USUAL LIMITS OF VARIATION	ESTIMATED AVERAGE	CONVENIENT APPROXIMATION
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Fat	3.0-6.0	4.00	4.0
Protein	3.0-4.0	3.33	3.3
Carbohydrate	4.6-5.0	4.85	5.0
Ash	0.70-0.78	0.72	0.7
Solids-not-fat	8.5-9.5	8.90	9.0

It will be noted that the fat is much the most variable constituent and that the protein varies about one third as much as the fat. In general the variations in the protein content are in the same direction as the fat. Thus genuine milk with 3 per cent fat averages about 3 per cent protein; with 4 per cent fat about 3.33 per cent protein; with 5 per cent fat about 3.66 per cent protein; with 6 per cent fat about 4 per cent protein. Such differences in fat and protein content are usually accompanied by very little variation in the percentages of milk sugar and ash.

Another way of expressing the relationship of the constituents is that the proteins usually constitute about one fourth of the total solids, the remainder of the fluctuations in total solids being almost entirely due to the fat.¹

Such statements as the above express average relationships. It is not to be expected that they will hold true for every sample. Marked departure from these relationships is, however, an occasion for suspicion when observed in market milk, because such milk is nearly always the mixed product of an entire herd (often of several herds) and is therefore not normally subject to such fluctuations in composition as is the milk of individual cows.

Another fact worthy of note is that very rarely if ever are minimum or maximum percentages of all constituents found in any one sample of genuine milk. For this reason the figures

¹ For further data see *Methods of Organic Analysis*, Revised Edition, pages 349-352.

for usual limits of variation in solids-not-fat in the above table do not exactly coincide with the summation of the corresponding data for proteins, carbohydrate, and ash.

In many cases it is convenient to consider the solids of milk simply in terms of fat and of solids-not-fat. In fact this is usually considered sufficient in the formulation of legal standards of composition, as will be seen below.

Adulteration and Inspection

Milk may be deliberately adulterated or it may become an adulterated product (within the present meaning of the term) through contamination or deterioration.

The principal forms of deliberate adulteration to which milk is subjected are watering, skimming, the addition of preservatives, and attempts to conceal inferiority by the use of artificial color or thickening agents, and by the addition of sodium bicarbonate to disguise the fact that the milk has begun to sour.

In most localities all these practices are made illegal either by specific prohibition or by some general provision that milk to which anything has been added or from which anything has been abstracted shall be deemed adulterated.

Watering is of course the simplest form of adulteration and is objectionable both as a fraud and as a source of contamination. A large part of the contamination of milk comes from the use of impure water in washing utensils, etc., and if such water is added to the milk in any quantity, the contamination will of course be much more serious. In most localities the watering of milk is much less common now than formerly.

Skimming, by which is meant either the removal of a part of the cream or the addition of skimmed or partially skimmed milk, is probably more common than watering. As the same farmer often sells both milk and cream, the temptation to remove a part of the cream before selling the milk (especially if the milk originally contains considerably more fat than the law requires)

is obvious. The fact that some state standards require a high content of solids-not-fat and a relatively low fat content constitutes an incentive to partial skimming.

Artificial color is occasionally added to restore the yellow tint of milk which has been partially skimmed or to make a milk which is naturally of poor quality appear richer than it is.

Addition of preservatives is not as common now as formerly, at least in cities having systematic milk inspection. The preservatives chiefly used are formaldehyde and boric acid or borax. At present these preservatives appear to be less commonly sold by dairy supply houses, and their use is largely restricted to small towns having no milk inspection and to hotels and restaurants which may add preservatives to their milk after purchase in order to diminish the necessity for strict refrigeration and the chances of souring when kept on hand to meet an uncertain demand. An investigation in Chicago showed a much larger proportion of cases of added preservatives in the samples of milk from hotels and restaurants than in the samples taken from milk dealers.

Contaminated or deteriorated milk can be treated as adulterated under that clause of the Food and Drugs Act which declares a food to be adulterated if it consists in whole or in part of "a filthy decomposed or putrid animal or vegetable substance." As will be evident from the section which follows, the sanitary quality as well as the chemical composition of milk is now regarded as a proper matter for standardization.

The conduct of inspection. Practices differ greatly in regard to milk inspection. Municipal authorities usually have wide discretion in the matter, under their general "police powers," and city ordinances often go much farther than state legislation in attempts to control the milk supply. City boards of health often have inspectors in the country to visit farms and receiving stations as well as in the city to inspect the milk as it comes to market and as it is offered for sale.

The sanitary conditions of production and handling reported by the country inspectors may be made the basis of renewal or

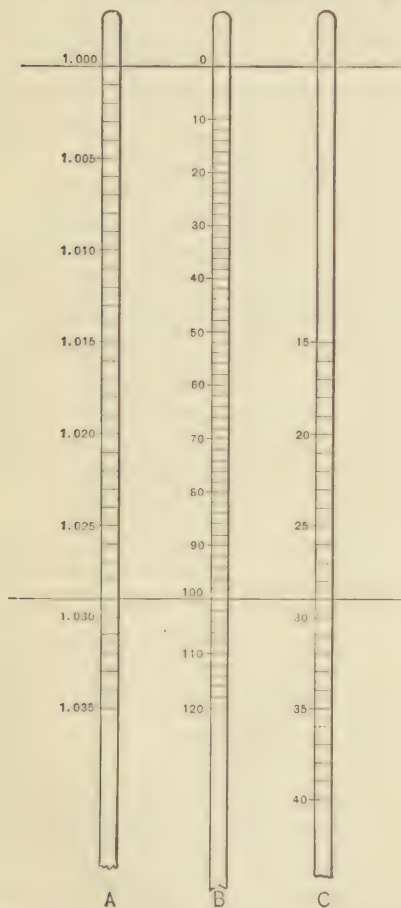


FIG. 3.—Lactometer scales: A, hydrometer; B, New York City Board of Health lactometer; C, Quevenne lactometer. (From Wing's *Milk and its Products*.)

revocation of the permit to sell milk in the city or of the classification or designation under which it may be sold. The city inspectors seek to detect or prevent unsanitary practices in the city and the sale of milk which has been skimmed or watered or is otherwise adulterated or deteriorated.

Thermometer and lactometer tests. As preliminary tests the city milk inspector often takes the temperature of the milk and its reading on the *lactometer*, which is merely a hydrometer so constructed as to cover a sufficient range in density to include all qualities of milk. Milk showing too high a temperature is sometimes destroyed forthwith. In other cases the high temperature is construed simply

as requiring a laboratory examination for bacteria. A low lactometer reading is not sufficient in itself to condemn milk, but aids the inspector to judge whether further examination is necessary.

The lactometer may be graduated to read specific gravity or on an arbitrary scale. The New York Board of Health lactometer has an arbitrary scale of which the zero point coincides with a specific gravity of 1.000 and the 100 point with a specific gravity of 1.029. Figure 3 shows the different lactometer scales side by side.

Whole milk normally has a specific gravity of 1.029 to 1.035; usually 1.030 to 1.033, and should therefore read more than 100 on the New York Board of Health lactometer.

The specific gravity or lactometer reading of milk is lowered either by addition of water or addition of cream; but milk which is naturally rich in fat, being usually rich in protein also, ordinarily has a higher specific gravity or lactometer reading than the average. If in addition to the lactometer reading the viscosity and opacity of the milk be observed by carefully watching the lactometer bulb on lifting it out of the milk, it is possible for an experienced inspector to form a fairly reliable impression as to whether the milk is open to suspicion and should be sampled for laboratory analysis.

Chemical analysis when made for purposes of inspection consists usually in determining the percentages of fat and of total solids or solids-not-fat and testing for preservatives. (See *Methods of Organic Analysis*, Revised Edition, Chapters XVII and XVIII.)

The sediment test consists usually in straining a pint of the milk through a cotton disk one inch in diameter and then noting the appearance of the disk, which may be pure white, light gray, or brown, according to the cleanness of the milk. The disks can easily be dried and mailed to the farmer or milk dealer concerned, and their significance may be appreciated without a

knowledge of chemistry or bacteriology. This test is fully described and illustrated in Circular of Information 41, of the Wisconsin Agricultural Experiment Station.

The bacteria test consists in mixing a known small volume of the milk (previously diluted with sterilized water if necessary) with a nutrient medium in a flat-bottomed glass dish (Petri plate), keeping covered at a favorable temperature for one or two days, and then counting the number of colonies as an indication of the number of bacteria originally present. These methods are fully described in text books of bacteriology, and in a special bulletin of the American Public Health Association.

Standards of Purity

Since skimming and watering are the two chief forms of adulteration which directly affect the composition and food value of milk, any specific standard of composition should set a minimum limit for fat to guard against skimming and a minimum limit for solids-not-fat to guard against watering.

The National law sets no such specific standards but in the administration of the law the following standard proclaimed by the Department of Agriculture on recommendation of the Association of Official Agricultural Chemists is commonly followed:

Milk is the fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving, and contains not less than 8.5 per cent of solids-not-fat and not less than 3.25 per cent of milk fat.

Most of the state laws definitely prescribe that all milk offered for sale shall contain not less than certain percentages of fat and of total solids or solids-not-fat.

The principal state standards are shown in Table 3:

TABLE 3. STATE STANDARDS FOR MILK

STATE	FAT	SOLIDS- NOT-FAT	TOTAL SOLIDS
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Arkansas	3.25	8.5	—
California	3.0	8.5	11.5
Colorado	3.0	—	—
Connecticut	3.25	8.5	11.75
District of Columbia	3.5	9.0	12.5
Florida	3.25	8.5	11.75
Georgia	3.25	8.5	11.75
Hawaii	3.0	8.5	11.5
Idaho	3.2	8.0	11.2
Illinois	3.0	8.5	11.5
Indiana	3.25	8.5	—
Iowa	3.0	—	12.0
Kansas	3.25	8.5	11.75
Kentucky	3.25	8.5	—
Louisiana	3.5	8.5	—
Maine	3.25	8.5	11.75
Maryland	3.5	—	12.5
Massachusetts	3.35	—	12.15
Michigan	3.0	—	12.5
Minnesota	3.25	—	13.0
Missouri	3.25	8.75	12.0
Montana	3.25	8.5	11.75
Nebraska	3.0	—	—
New Hampshire	—	—	12.0
New Jersey	3.0	—	11.5
New York	3.0	—	11.5
Nevada	3.25	8.5	11.75
North Carolina	3.25	8.5	11.75
North Dakota	3.0	9.0	12.0
Ohio	3.0	—	12.0
Oklahoma	3.25	8.5	—
Oregon	3.2	9.0	—
Pennsylvania	3.25	—	12.0
Porto Rico	3.0	9.0	12.0
Rhode Island	2.5	—	12.0
South Dakota	3.5	8.5	—
Tennessee	3.5	8.5	—

TABLE 3. STATE STANDARDS FOR MILK — Continued

STATE	FAT	SOLIDS- NOT-FAT	TOTAL SOLIDS
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Utah	3.2	9.0	12.0
Vermont	—	9.25	12.5 ¹
Virginia	3.25	8.5	11.75
Washington	3.25	8.75	12.0
Wisconsin	3.0	8.5	—
Wyoming	3.25	8.5	—
Texas	3.25	8.5	—

¹ During May and June, 12.0 per cent.

It will be seen that there is considerable diversity of standards among the states. Since the fat content of milk is so variable some difference of opinion as to the proper legal minimum of fat is readily understood, but there is no justification in the natural composition of milk for setting a low standard for fat and at the same time a high standard for solids-not-fat, or total solids as is still done in several states. The explanation for such disproportionate standards is to be found in the fact that methods of milk analysis formerly used tended to underestimate the fat and overestimate the other solids.

The Commission on Milk Standards appointed with a view to securing uniformity of requirements among the different states and cities of the United States has recommended the general adoption of the standard calling for not less than 3.25 per cent of milk fat and not less than 8.5 per cent of milk solids-not-fat as proposed by the Association of Official Agricultural Chemists.

The Commission also recommended the adoption by communities of regulations providing for the sale of milk on a basis of guaranteed composition. The advantage of such a system is apparent from the fact that any single legal minimum must

necessarily be set considerably below the average in order to provide for natural variations in composition. Average milk and milk considerably below the average are thus equally legal, though of a very different value. It would obviously be fairer both to producer and to consumer if all milk could be sold on the basis of its true value.

In addition to standards of chemical composition several communities have adopted sanitary or bacteriological standards. Thus milk which contains visible dirt or more than a certain number of bacteria may be forbidden sale, or (as in the case of New York City) a maximum temperature may be prescribed on the ground that in warm milk bacteria multiply so rapidly as to make it a "decomposed substance" if not an actual menace to health. In the past such sanitary and bacteriological standards as have existed have varied much with the locality and have generally been regarded as more or less tentative.

The Commission on Milk Standards devoted special attention to the matter of sanitary and bacteriological standards and recommended the following classification of milk in which the definition of each class includes a statement of the maximum number of bacteria to be permitted and of the sanitary precautions to be prescribed.

Classification recommended by Commission on Milk Standards

GRADE A

Raw milk. Milk of this class shall come from cows free from disease as determined by tuberculin tests and physical examinations by a qualified veterinarian, and shall be produced and handled by employees free from disease as determined by medical inspection of a qualified physician, under sanitary conditions such that the bacteria count shall not exceed 100,000 per cubic centimeter at the time of delivery to the consumer. It is recommended that dairies from which this supply is obtained shall score at least 80 on the United States Bureau of Animal Industry score card.

Pasteurized milk. Milk of this class shall come from cows free from disease as determined by physical examinations by a qualified veterinarian and shall

be produced and handled under sanitary conditions such that the bacteria count at no time exceeds 200,000 per cubic centimeter. All milk of this class shall be pasteurized under official supervision, and the bacteria count shall not exceed 10,000 per cubic centimeter at the time of delivery to the consumer. It is recommended that dairies from which this supply is obtained should score 65 on the United States Bureau of Animal Industry score card.

(*Note.* The above represents only the minimum standards under which milk may be classified in grade A. The commission recognizes, however, that there are grades of milk which are produced under unusually good conditions, in especially sanitary dairies, many of which are operated under the supervision of medical associations. Such milks clearly stand at the head of this grade.)

GRADE B

Milk of this class shall come from cows free from disease as determined by physical examinations, of which one each year shall be by a qualified veterinarian, and shall be produced and handled under sanitary conditions such that the bacteria count at no time exceeds 1,000,000 per cubic centimeter. All milk of this class shall be pasteurized under official supervision, and the bacteria count shall not exceed 50,000 per cubic centimeter when delivered to the consumer.

It is recommended that dairies producing grade B milk should be scored and that the health departments or the controlling departments, whatever they may be, strive to bring these scores up as rapidly as possible.

GRADE C

Milk of this class shall come from cows free from disease as determined by physical examinations and shall include all milk that is produced under conditions such that the bacteria count is in excess of 1,000,000 per cubic centimeter.

All milk of this class shall be pasteurized, or heated to a higher temperature, and shall contain less than 50,000 bacteria per cubic centimeter when delivered to the customer. It is recommended that this milk be used for cooking or manufacturing purposes only.

Whenever any large city or community finds it necessary, on account of the length of haul or other peculiar conditions, to allow the sale of grade C milk, its sale shall be surrounded by safeguards such as to insure the restriction of its use to cooking and manufacturing purposes.

The above recommendations have been indorsed by the American Public Health Association, the American Medical Association, and the Conference of State and Provincial Boards of Health of North America.

Detailed Composition

The fat of milk is characterized both by its emulsified form and by containing 5 to 7 per cent of butyrin which when split yields butyric acid, the volatile acid to which the odor of rancid butter is largely due. Smaller quantities of other volatile acids are also present in combination as fats. While these acids are volatile when free, the compounds (glycerides) in which they occur in milk and sound butter are not volatile.

Of the three substances of which most edible fats are chiefly composed — palmitin, stearin, and olein — the amount of palmitin in milk fat is fairly large; of stearin very small; of olein there is less than in most edible fats.

The chemical composition of the fat is more fully considered under butter in Chapter X.

The proteins of milk. From three fourths to four fifths of the nitrogenous matter of milk consists of caseinogen (casein, calcium-casein), while most of the remainder is in the form of lactalbumin.

Casein or caseinogen is the best known of the phosphoproteins. The chemical relationship between the caseinogen (or calcium-casein, or milk-casein) of normal milk and the casein of curd as obtained by acidulating the milk is not entirely clear. Studies of the composition of this protein have been made upon material purified by repeated precipitation. Its elementary composition is about as follows: carbon, 53.1 per cent; hydrogen, 7.0 per cent; oxygen, 22.5 per cent; nitrogen, 15.8 per cent; sulphur, 0.8 per cent; phosphorus, 0.8 per cent. The amounts of amino acids which have been obtained from it by hydrolysis are shown in Table 4.

Lactalbumin being present in milk in so much smaller quantity than caseinogen has not been so extensively studied. Its products of hydrolysis thus far determined are shown in Table 4. It will be seen that some of the amino acids probably present have not yet been determined; it is also probable that further study will show larger quantities of many of those amino acids for which figures have been reported.

TABLE 4. PERCENTAGES OF AMINO ACIDS FROM MILK PROTEINS ¹

AMINO ACID	CASEIN	LACTALBUMIN
Glycin	0.0	0.0
Alanin	1.5	2.5
Valin	7.2	0.9
Leucin	10.5	19.4
Prolin	6.7	4.0
Aspartic acid	1.4	1.0
Glutamic acid	15.55	10.1
Phenylalanin	3.2	2.4
Tyrosin	6.5	4.9
Serin	0.5	—
Oxyprolin	0.23	—
Histidin	2.5	1.5
Arginin	4.8	3.0
Lysin	7.6	8.1
Tryptophan	1.5	3.0
Cystin	0.1	—
Ammonia	1.6	1.3

By comparison with the corresponding data given in later chapters it will be seen that the yields of several of the more complex amino acids such as tryptophan, tyrosin, and lysin are distinctly higher from the milk proteins than from food proteins in general; while the amino acids lacking or present only in small quantity in milk proteins are those of which the body

¹ In general the highest yield of each amino acid is given since it is known that the methods used tend to give results below the truth.

may readily derive abundant supplies from other sources. (See also the sections on nutritive value and place in the diet in this and succeeding chapters.)

The ash constituents of milk include all of the so-called inorganic elements necessary to the normal nutrition of man. Some of these exist in the milk as salts, some as constituents of the organic matter, some in both forms.

Sulphur, of which milk contains about 0.03 per cent, exists almost entirely as a constituent of the milk proteins.

Phosphorus constitutes about 0.10 per cent of the fresh weight of milk (equivalent to 0.23 per cent phosphoric acid) and is present in at least four forms. About 65 per cent of the phosphorus of milk is in the form of phosphate in the sense that it is precipitable by phosphate reagents, but to what extent this is free phosphate and to what extent loosely combined with organic matter has not been determined; about 25 per cent exists as an essential organic constituent of the casein (the latter containing 0.8 to 0.9 per cent of phosphorus after having been purified by dissolving and reprecipitating until ash-free); about 3 per cent is in the form of lecithin; and about 7 per cent is in the form of organic compounds of other types (including the so-called "nucleon" of Siegfeld).

Chlorine exists in milk in the form of sodium chloride, possibly in part also as potassium chloride.

The base-forming elements, sodium, potassium, calcium, and magnesium, are present in milk in slightly greater amounts than would be necessary to neutralize the acids obtainable from the sulphur, phosphorus, and chlorine present, and in distinct excess over what would be required to combine with the ready-formed acid radicles. This excess of base is combined in part with the casein and in part with citric acid, a small quantity of which is a normal constituent of milk and is counted with the carbohydrates in the usual proximate analysis. The percentages of these elements, calculated as oxides, in average cows' milk are

as follows: calcium oxide, 0.168 per cent; magnesium oxide, 0.019 per cent; potassium oxide, 0.171 per cent; sodium oxide, 0.068 per cent.

Noticeable here are the high calcium content as compared with other foods and the richness of milk in calcium and potassium as compared with magnesium and sodium. In these respects the composition of milk ash resembles that of the ash of the animal body.

The iron of milk is small in amount (0.00024 per cent) but of high food value. It will be considered in the section on the nutritive value of milk and the place of milk in the diet.

Milk sugar and minor constituents. Milk sugar (lactose) is the only known carbohydrate of milk. The small amount of citric acid already mentioned as occurring in milk is usually counted with the milk sugar as carbohydrate.

Summary of constituents. The following tabular summary (p. 75) is added in order that the constituents already mentioned may not be understood to be the only substances which milk contains. Readers who wish further information regarding substances which can be merely mentioned here are referred to the books and journal articles listed at the end of the chapter.

Nutritive Value and Place in the Diet

Average milk with 4 per cent fat furnishes about 314 Calories per pound or 675 Calories per quart. Milk naturally so poor as to contain only 3 per cent fat would furnish 268 Calories per pound; natural milk with 5 per cent fat would furnish 360, and that with 6 per cent fat, 407 Calories per pound. In any of these cases from 18 to 20 per cent of the Calories would be furnished by protein.

The quantitative relations between protein content and fat content or fuel value are readily altered by separating the "top milk" or cream from the "skim milk." Milk skimmed so as

CONSTITUENTS OF MILK

		Per cent
Proteins		
Caseinogen		
Lactalbumin		
Lactoglobulin		
Fibrinogen		3.3
Amino acids		
Vitamines		
Enzymes		
Fats		
Butyrin	Glycerides of volatile acids	
Caproin		
Caprylin		
Caprin		
Laurin	Glycerides of non-volatile acids	
Myristin		
Palmitin		4.0
Stearin		
Olein		
Lipoids (fatlike substances)		
Lecithin		
Cholesterin		
Probably other lipoids		
Carotin (lipochrome)		
Milk Sugar		4.8
Citric acid		0.1
Ash Constituents		
Sulphur		
Phosphorus (calc. as P_2O_5)		
Chlorine		
Sodium (calc. as Na_2O)		
Potassium (calc. as K_2O)		0.7
Calcium (calc. as CaO)		
Magnesium (calc. as MgO)		
Iron		
Iodine		
Water		87.1
		100.0

to contain only 1 per cent fat would yield about 200 Calories per pound and protein would furnish approximately one third of the Calories; while a thin cream obtained from the same milk and containing 10 per cent fat would yield about 550 Calories per pound, of which only one tenth of the Calories would be furnished by protein.

Even from the standpoint of gross proximate composition and fuel value, milk is a fairly economical food, especially when compared with other foods of animal origin, a quart of milk being approximately equivalent to a pound of steak ¹ or to eight or nine eggs.

Such a comparison, however, fails to do justice to the true nutritive value of milk, which is largely due to the peculiar nature of its constituents.

The carbohydrate of milk (lactose) is already in solution and like other sugars does not require the action of the salivary or pancreatic juice, but only of the intestinal juice, for its digestion. It has the advantage over sucrose and glucose of being less susceptible to fermentation and less liable to irritate the stomach.

The fat of milk is already emulsified and so is more readily available to the body than the fats of other common foods except eggs. The fact that milk fat is fluid at body temperature also aids its digestibility. Whether the presence of glycerides of the volatile acids is of any special advantage aside from flavor is not clear.

The proteins of milk are of high nutritive value. When

¹ That the standard tables of analyses give an exaggerated impression of the fuel value of meats, especially beef, is explained in Chapter VI preceding Table 12. In that table it will be seen that sirloin steak as purchased is given a fuel value of 960 Calories per pound, but this includes all the fat originally belonging with the cut, and two thirds of the Calories come from the fat. If, as is often the case, the butcher and consumer remove one half or more of the fat originally present, then the steak as actually eaten furnishes not over 640 Calories for each pound of material purchased.

milk is taken under normal conditions (even in relatively large quantity and in connection with only a small amount of bread or other solid food), about 97 to 98 per cent of the milk protein is digested and absorbed. Numerous recent digestion and metabolism experiments indicate that under normal conditions it is as completely digested and absorbed as any of the food proteins, and has the advantage of not containing the substances which yield uric acid in the body, nor being readily susceptible to intestinal putrefaction.

Not only do the milk proteins show a high coefficient of digestibility, but metabolism experiments and clinical observations show that milk furnishes a form of protein food particularly adapted to bring about a storage of protein in the body. This may be due in part to the fact that casein contains phosphorus as an essential constituent, since Rosemann has shown that storage of both nitrogen and phosphorus is more readily obtained with a diet of phosphoproteins than with mixtures of simple proteins and inorganic phosphates, but it is doubtless more largely due to the amino-acids content of the milk proteins.

If the data on page 72 be compared with the corresponding data for proteins of other foods as given in later chapters, (Tables 9, 18, 26, 38, 41, 44), it will be seen that the milk proteins are relatively rich in the amino-acid radicles of more complex structure, which apparently are not readily formed in the body, and especially tryptophan and lysin, which are known to play an especially important part in nutrition and growth. The ash constituents of milk are important not only for their property of being adequate in the absence of all other ash constituents, as in the experiments just cited, but also in their bearing upon the adequacy of the phosphorus, calcium, and iron supply in a mixed diet.

Phosphorus compounds are present in milk in relative abundance and in a variety of forms, as was shown in the discussion of the chemical composition of milk (page 73).

Calcium is present in still greater relative abundance. Milk contains slightly more calcium, volume for volume, than does limewater. As a rule the calcium content of the diet depends mainly upon the amount of milk consumed. In family dietaries where ordinary quantities of milk are used, the milk is apt to furnish about two thirds of the total calcium of the diet. Without milk it is unlikely that the diet will be as rich in calcium as is desirable either for the child or for the adult.

Iron is present in milk in only small quantity, but evidently in a form exceptionally favorable for assimilation. Notwithstanding the low iron content, a diet of milk and white bread appears to be adequate for the maintenance of iron equilibrium in man, whereas white bread alone in larger quantity or a diet of bread and iron-free protein is much less efficient.

So far as our present knowledge indicates, this favorable influence of milk upon the iron metabolism in spite of the small amount of iron which it contains would seem to be due in part to the particular organic form of combination in which the iron is present and in part to the fact that it is associated with a large amount of calcium which in some way appears to be favorable to the economy of iron in the organism.¹

Recent research makes it plain that milk contains substances other than the known proteins, fats, carbohydrates, and salts which perform important nutritive functions especially in relation to growth. Osborne and Mendel in their feeding experiments with isolated foodstuffs found that when the fats and proteins are removed from milk the residue is more efficient in nutrition than is a mixture of milk sugar and salts. Still more recently it has been found both by McCullom and Davis and by Osborne and Mendel that milk (or butter) contains a fatlike (or fat-soluble) substance, whose presence or absence in an otherwise adequate diet determines the continuance or cessation

¹ For discussion of the iron content of milk in relation to infant feeding see *Chemistry of Food and Nutrition*, Chapter IX, pages 253-255.

of growth in young animals. Hopkins showed that even small amounts of milk exert a very marked influence upon the growth of young animals kept on a diet of artificially "purified" food materials. Some of Hopkins' results are shown in the accompanying cuts. Figure 4 shows the growth curves of rats with and without a small amount of milk when the rest of the diet was of artificially purified food. Figure 5 shows the results of a similar experiment in which on the 18th day the milk was transferred from one set of rats to the other. Note in both cases the failure of growth on the diet of artificially purified foodstuffs alone and the rapid growth when a small amount of milk was fed.

Taking into consideration the many and important factors which increase the value of milk as food, above that indicated

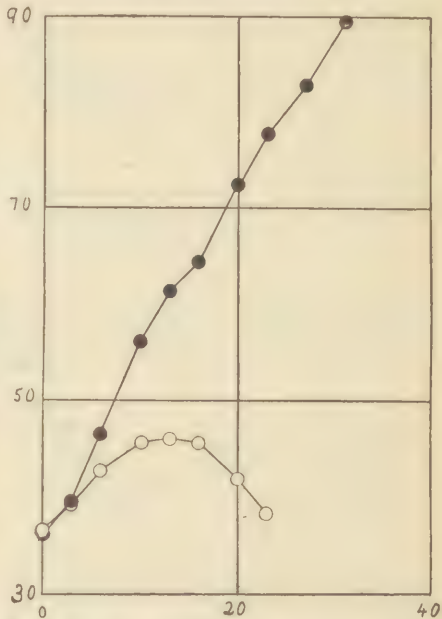


FIG. 4. — Growth curves of rats. Lower curve six rats on artificial diet alone. Upper curve six similar rats receiving in addition 2 cc. of milk each per day. Abscisse time in days; ordinates average weight in grams. (Courtesy of Dr. F. Gowland Hopkins.)

by its mere proximate composition and fuel value, and also the fact that it requires no preparation and has no waste, it is believed to be true economy to make liberal use of milk in the diet so long as the milk does not cost more than twice as much in

proportion to the energy it furnishes as the average of the food eaten. On this basis families who must live on as little as 16 to 20 cents per person per day for food may wisely use reasonable quantities of milk at 8 to 10 cents per quart, balancing this by a larger use of such food as bread, which furnishes energy much

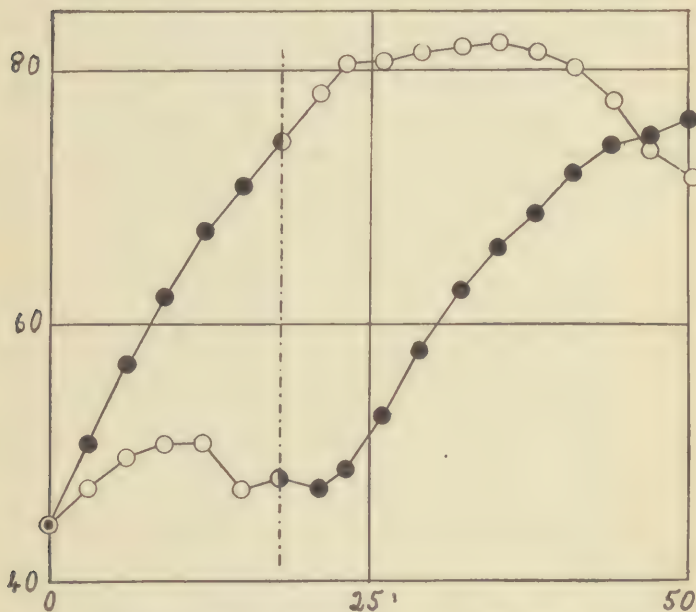


FIG. 5. — Growth curves of rats. Lower curve (up to 18th day) represents rats on purified food; upper curve similar rats having 3 cc. milk each per day in addition to this food. On the 18th day, marked by the vertical dotted line, the milk was transferred from one set to the other. Abscissa time in days; ordinates average weight in grams. (Courtesy of Dr. F. Gowland Hopkins.)

more cheaply than the average food of the diet. Those who are able to spend 30 to 40 cents per person per day for food are practicing true economy when they buy and use liberally the best milk obtainable even at a price of 15 to 20 cents per quart.

Especially in the feeding of children should milk be used freely, because of its many advantages as a " tissue-building " and " growth-promoting " food. " A quart of milk a day for every child " is a good rule easy to remember.

In no other way can the food habits now prevailing, especially in the cities, be so certainly and economically improved as by a more liberal use of good milk.

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¹ The first group (I) contains books (and a few of the more comprehensive bulletins) arranged alphabetically by authors. The second group (II) contains contributions to scientific journals and other periodicals, reports, bulletins, etc., arranged chronologically. Similar lists will be found at the end of each of the chapters which follow.

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CHAPTER IV

CHEESE AND MISCELLANEOUS MILK PRODUCTS

Cheese

CHEESE was probably the first product manufactured from milk and the first form in which milk was preserved for future use.

It has for centuries been an important article of diet in many countries, and is made in a great variety of forms. A recent compilation by Doane and Lawson describes no less than 350 varieties of cheese.

Until the middle of the last century the making of cheese was a household or farm industry. The first cheese factory was started by Jesse Williams, a farmer of Oneida County, New York, who, finding that his cheese sold readily at more than the average price, began in 1851 to buy the milk of his neighbors and manufacture cheese from it as well as from the milk produced on his own farm. Within fifteen years his example had been followed to such an extent that there were about five hundred cheese factories in New York State alone.

It is estimated that in 1850 there was made in the United States about 100,000,000 pounds of cheese, all of it on farms or in the household; in 1900, about 300,000,000 pounds, of which 96 to 97 per cent was made in factories.

The census of manufactures of 1909 (which of course would not include the cheese made on farms) estimates the production for the United States at about 311,000,000 pounds worth at wholesale at the factory \$43,000,000. The amount of cheese

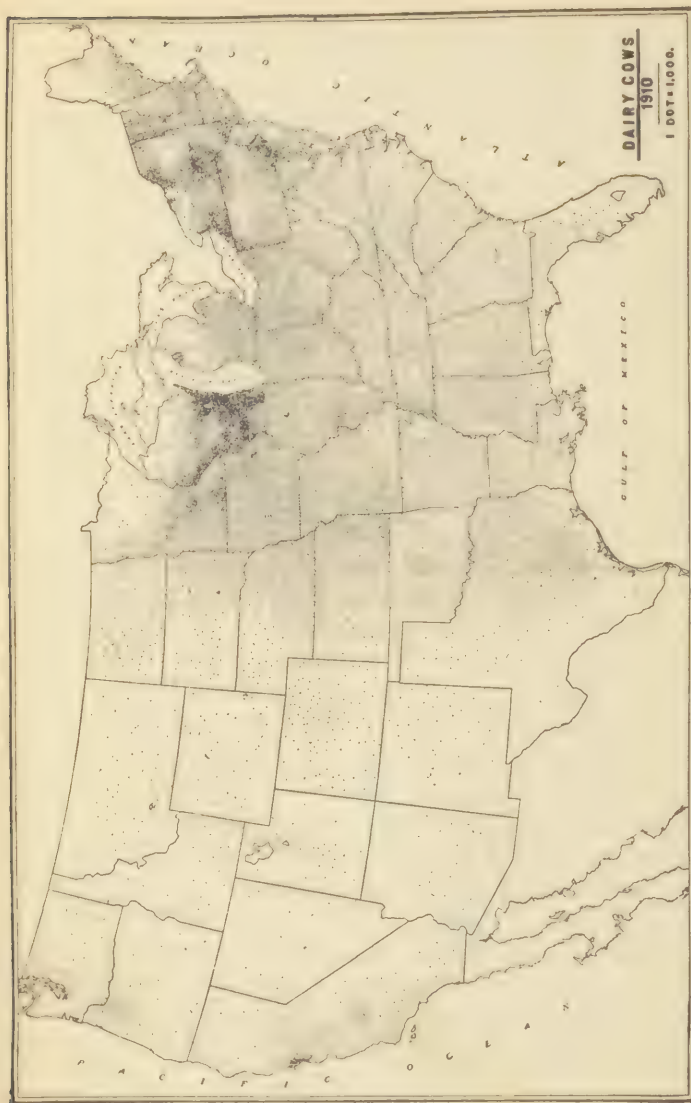


FIG. 6. — Distribution of dairy cows in the United States (census of 1910). Reproduced by permission from Director's Report of the Wisconsin Agricultural Experiment Station.

imported exceeded that exported by about 20,000,000 pounds. The cheese consumption in this country was therefore about $3\frac{1}{2}$ to 4 pounds per person per year, a low figure in comparison with the amounts of meat and butter consumed. During the past few years the United States Department of Agriculture has given considerable attention to the cheese industry and to the use of cheese as a food, and it is probable that this will result in a larger per capita consumption of cheese for the country as a whole.

Cheese is roughly divided into two main types: the hard cheeses such as Cheddar, Edam, Emmental (or Swiss), Parmesan and Roquefort; and the soft cheeses such as Brie, Camembert, Gorgonzola, Limburg, Neufchâtel, and Stilton.

Much the largest part of the cheese made in this country is of the type of the Cheddar cheese and is therefore properly known as American Cheddar cheese, although frequently called simply "American cheese" or, in the trade, "standard factory cheese." In addition to this standard type of cheese smaller quantities of other types are made. Some New York factories make cheeses of the Brie, Camembert, and Neufchâtel types, while cheeses of the Swiss and of the Limburg types are made in Wisconsin.

The principal importations of cheese into the United States are of Parmesan and Gorgonzola cheese from Italy; Emmental cheese from Switzerland; Roquefort, Camembert, and Brie, from France; and Edam cheese from Holland. Many other varieties are imported in small amounts. Since these cheeses are imported largely as delicacies, they are more costly than standard American cheese.

The chief cheese-producing states are New York and Wisconsin, the main cheesemaking centers very nearly coinciding with the regions having greatest numbers of dairy cows as shown on the accompanying map (Fig. 6).

Manufacture of American Cheddar Cheese

This process is divided into several fairly distinct steps as follows: (1) inspection of milk, (2) ripening of milk, (3) addition of color — when color is used, (4) coagulating the milk, (5) cutting the curd, (6) stirring and heating the curd, (7) removing whey, (8) cheddaring the curd, (9) milling the curd, (10) salting and pressing the curd, (11) ripening or curing the cheese.

Inspection of milk. Each can of milk received for cheesemaking should be examined for acidity, dirt, and abnormal flavors (odor or taste). Sometimes a rapid examination by the senses of sight and smell is deemed sufficient; sometimes a roughly quantitative determination of the acidity is made. When the cheesemaker is troubled with abnormal fermentation or defective curd, it may be necessary for him to make a test of each farmer's milk to determine the nature of the fermentation which it shows and of the curd which it yields, in order that the particular milk which is responsible for the trouble may be located and excluded.

Ripening of milk. This consists in keeping the milk at about 86° F. (30° C.) until the desired amount of lactic acid has formed. "Starters," consisting of commercial cultures of lactic acid bacteria or of milk in active lactic acid fermentation, are sometimes added to facilitate the ripening process. The lactic acid is important in its influence on the operations of cheesemaking and its presence also tends to repress abnormal fermentations. The proper degree of ripeness is judged either by titrating for acidity or by testing a portion of the milk with rennet to see whether it coagulates as readily as is desired. Acidity equivalent to 0.20 per cent of lactic acid usually marks the completion of the ripening process.

Addition of color. When coloring matter is used in cheesemaking, it should be added to the ripened milk just before coagulating it with rennet.

Coagulating the milk. Rennet is the most useful reagent for the precipitation of the curd, that prepared from the calves' stomachs being most highly prized for cheesemaking. Rennet is now prepared on a large scale and is purchased from the makers for use in the cheese industry. The quality of the rennet is very important, as an inferior grade gives a bad taste to the cheese. The amount of rennet to be added depends, of course, upon the strength of the preparation, but should be sufficient so that when mixed with the milk and kept at 84°-86° F. the milk will be curdled in 15 to 20 minutes if it is to be used for a quick-curing cheese, and in 30 to 40 minutes for a slow-curing cheese. The rennet extracts commonly used are added in the proportion of from 2 to 5 ounces per 1000 pounds of milk. Before adding, the extract should be diluted with 40 times its volume of water at a temperature of 85-90° F. so as to prevent the production of a lumpy curd. Previous to adding the rennet the milk is thoroughly stirred in order to distribute the fat evenly, and the rennet is added evenly and slowly with constant stirring, which is continued for several minutes. After this, the milk is stirred gently near the surface to prevent separation of cream. All stirring is stopped as soon as (or before) coagulation begins, and the milk is then left covered and undisturbed while the coagulation gradually continues until the whole mass forms one coherent curd and is ready for cutting.

Cutting the curd. In order that the whey may be separated it is necessary that the curd be cut into pieces; the smaller the pieces of curd, the more rapidly will the whey escape. As soon as the curd is formed it tends to contract and force out a portion of the whey. By cutting the curd the surface from which the whey can exude is increased and so the separation of the whey from the curd goes on much more rapidly. The time for cutting the curd is important and is determined by the skill and experience of the cheesemaker. If the curd is cut when it is too soft, there may be a large loss of fat, with a resulting decrease in the

yield and quality of the cheese. If the curd is allowed to become too hard before cutting, the whey is removed with greater difficulty; and if incompletely removed, a cheese of low quality results. The cutting is accomplished by drawing specially devised cutting knives through the mass of curd, both horizontally and vertically, so as to cut it into cubes of one quarter to one half inch size.

Stirring and heating the curd. As soon as the curd is cut, the whey begins to separate, and the mass of cut curd is then kept in gentle motion by stirring, taking care to avoid breaking the cubes. This results in the separation of a clear whey, free from fat or small particles of curd. The curd contracts and hardens during this process and soon reaches a condition in which the surfaces do not readily adhere. During this process of separation of the whey, the temperature is raised to about 90° F. and finally toward the last to about 98° F.

Removing the whey. The precipitated curd is left in contact with the whey for some time, during which time there is some action of the acid of the whey upon the protein of the curd, which is allowed to continue until a small mass of the curd, which has been squeezed in the hand to remove the whey and then pressed against a bar of iron heated a little below redness, will leave adhering to the iron fine, silky threads, the length of which indicates roughly the extent to which the desired combination of acid and protein has taken place. Usually the curd is separated when the hot iron test shows strings about one eighth of an inch long; but other tests are also used to aid in judging when the whey should be removed. The whey is run off gradually while the stirring of the curd is continued.

Cheddaring the curd. Most of the whey having run off, the cubes of curd are left piled in the bottom of the vat until they mat or pack together, which process is technically known as "cheddaring." Sometimes the "cheddaring" is accomplished in a special apparatus called the "curd sink." When the ched-

daring of the curd is complete, it is cut into blocks, 6 to 12 inches in each dimension, which are turned in the vat in order to facilitate the further removal of whey, and are then carefully placed, one over the other, until they form a large mass. The process of solidifying or "cheddaring" has two results: first, the more complete removal of the whey, and second, the formation of a characteristic texture in the curd which becomes less rubber-like and more velvety and forms strings of an inch or more in length when tested with the hot iron. During the cheddaring a considerable increase of acidity occurs, the last of the whey which drains from the piled curd showing usually an acidity equal to 0.6 to 0.9 per cent of lactic acid.

Milling the curd. The milling process consists in cutting the lumps of curd into small pieces of uniform size in order that it may be salted more evenly and handled more readily when it is placed in hoops for pressing. This is done by means of curd-mills designed to avoid as far as possible the loss of fat which would result from crushing or squeezing the curd.

Salting and pressing. Salt is added chiefly for flavoring, but also it aids in removing the whey, it hardens the curd, it checks the further formation of lactic acid, and it helps to prevent the development of undesirable fermentation. Excessive salting is, however, injurious. Usually from 1 to 3 pounds of salt are added to the curd obtained from 1000 pounds of milk. After filling the curd into the mold it is pressed in the proper form by a uniform pressure which is continued for 24 to 48 hours. Usually a light pressure is applied at first and gradually increased during about an hour, when the cheese is removed, trimmed, turned, wrapped in cloth, and replaced for the final pressing.

Ripening or curing the cheese. When taken from the press cheese is said to be unripe, green, or uncured. It must be stored for weeks or months to become properly ripened. The higher the temperature to which cheese is exposed in ripening, the more rapid the process will be, but this is attained usually at the

expense of the quality of the cheese. For the best results, the ripening is conducted at a temperature not above 55° F. and requires a comparatively long time. During the ripening the cheese undergoes some loss of weight by evaporation of moisture, but the chief object of the ripening process is to secure certain changes in texture and flavor which depend essentially upon a gradual hydrolysis of the cheese protein, the changes being very similar to those which take place in digestion.

The increase of soluble proteins, and of the products of further cleavage, which takes place at the expense of the insoluble protein of the original curd, is shown in Table 5, which is condensed from data given by Van Slyke and Publow.¹

TABLE 5. SHOWING DEVELOPMENT OF PROTEIN CLEAVAGE PRODUCTS IN CHEESE

AGE OF CHEESE	NITROGEN, EXPRESSED AS PERCENTAGE OF THE TOTAL NITROGEN OF THE CHEESE, IN THE FORM OF:				
	Soluble Pro- teins and De- rivatives	Proteoses	Peptones	Amino Acids	Ammonia
<i>Months</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
1½	21.44	3.15	3.84	9.88	1.56
3	30.98	4.56	4.65	14.36	2.45
6	36.15	4.92	4.22	19.96	3.52
9	43.45	4.59	3.56	26.53	4.74
12	44.75	4.16	3.95	28.38	5.41
18	47.25	3.88	2.57	30.46	6.62

The changes which take place in the cheese protein during the ripening process are doubtless due to a combination of factors. Van Slyke holds that (1) the lactic acid, (2) the rennet enzyme, (3) the milk enzyme (galactase), (4) microorganisms, chiefly bacteria, all play important parts in the ripening process. The

¹ *The Science and Practice of Cheesemaking*, page 337.

exact part played by each of these factors is still a subject of investigation.

Other Varieties of Cheese

Since about three fourths of all the cheese used in the United States is of the Cheddar type, only that type can be considered at all fully here. The following statements regarding a few other varieties of cheese are abbreviated from the descriptions given by Doane and Lawson.¹

Brie. This is a soft rennet cheese made from cows' milk. The cheese varies in size and also in quality, depending on whether whole or partly skimmed milk is used. The method of manufacture closely resembles that of Camembert.

This cheese has been made in France for several centuries. Mention was made of it as early as 1407. It is made throughout France, but more extensively in the Department of Seine et Marne, in which it doubtless originated. More or less successful imitations of this cheese are made in other countries. It was estimated that 7,000,000 pounds of Brie cheese were sold in Paris during 1900. The export trade is also very important.

Camembert. This is a soft rennet cheese made from cows' milk. A typical cheese is about $4\frac{1}{4}$ inches in diameter and $1\frac{1}{4}$ inches thick and is usually found on the market in this country wrapped in paper and inclosed in a wooden box of the same shape. The cheese usually has a rind about one eighth of an inch in thickness which is composed of molds and dried cheese. The interior is yellowish in color, and waxy, creamy, or almost fluid in consistency, depending largely upon the degree of ripeness.

Camembert cheese is said to have originated in 1791 in the locality from which it derives its name in the Department of Orne, in the northwestern part of France. The industry extended soon into Calvados, and these two departments are

¹ Varieties of Cheese: Descriptions and Analyses, United States Department of Agriculture, Bureau of Animal Industry, Bulletin 105.

still the principal seat of the industry. Very successful cheeses of this type have been made at the Storrs Agricultural Experiment Station in Connecticut.

Cheshire. This cheese is one of the oldest and most popular of the English varieties. It is a rennet cheese made from unskimmed cows' milk, and is named for Chester County, England, where it is largely produced. It is made in cylindrical shape from 14 to 16 inches in diameter, and weighs 50 to 70 pounds. In making this cheese sufficient annatto is used to give the product a very high color.

Cheshire-Stilton. This is a combination of the Cheshire and Stilton varieties of cheese in which the general characteristics of size and shape and manufacture of the Cheshire are retained, and a growth of the mold peculiar to Stilton is secured. The mold is propagated by keeping out each day a portion of curd and mixing it with some older curd in which the mold is growing well.

Edam. This is a hard rennet cheese produced in Holland; it is also known as Katzenkopf, Tete de Maure, and Manbollen. The best of the product is made of unskimmed cows' milk, but much of it at the present time is made from milk which has had at least one half of the fat removed. The cheeses are round and are colored deep red on the surface or wrapped in tin foil.

When the cheese is one month old it is washed in water at 70° F. for twenty minutes and then placed in the sun to dry, after which it is rubbed with linseed oil. Before shipping the cheese is colored, usually red, but for some markets it is colored yellow with annatto. This coloring is done with a watery solution of litmus and Berlin red, or with carmine. A considerable quantity of this cheese is imported into the United States. At the present time some Edam cheeses are inclosed in air-tight tins for export.

Emmental. This is a hard rennet cheese made from unskimmed cows' milk, and has a mild, somewhat sweetish flavor. It is characterized by holes or eyes which develop to about the

size of a half inch in typical cheeses and are situated from 1 to 3 inches apart. Cheese of the same kind made in the United States is known as Domestic Swiss, and that made in the region of Lake Constance is called *Algau Emmental*.

Emmental cheese is a very old variety. In the middle of the fifteenth century a cheese probably of this type was manufactured in the Canton of *Emmental*. In the middle of the seventeenth century the industry was well developed and genuine *Emmental* cheese was being exported. In 1722 its manufacture under the name of *Gruyère* is recorded in France, two coöperative societies having been organized for this purpose.

Emmental cheese is now manufactured in every civilized country. In the United States there are many factories, located principally in Wisconsin, New York, and Ohio. In Switzerland the greater part of the milk produced is made into this product, and large districts in France and northern Italy are devoted to its manufacture. The best of the product made in Switzerland is exported, about 5,000,000 pounds coming to the United States annually.

Gorgonzola. This variety, known also as *Stracchino di Gorgonzola*, is a rennet Italian cheese made from whole cows' milk. The name is taken from the village of *Gorgonzola*, near Milan; but very little of this cheese is now made in that immediate locality. The interior of the cheese is mottled or veined with a penicillium much like *Roquefort*, and for this reason the cheese has been grouped with the *Roquefort* and *Stilton* varieties. As seen upon the markets in this country, the surface of the cheese is covered with a thin coat resembling clay, said to be prepared by mixing barite or gypsum, lard or tallow, and coloring matter. The cheeses are cylindrical in shape, being about 12 inches in diameter and 6 inches in height, and as marketed are wrapped in paper and packed with straw in wicker baskets.

The manufacture of *Gorgonzola* cheese is an important industry in Lombardy, where formerly it was carried on prin-

cipally during the months of September and October, but with the establishment of curing cellars in the Alps, especially near Lecco, the manufacture is no longer confined to this season.

At an early stage in the process of ripening the cheese is usually punched with an instrument about 6 inches long tapering from a sharp point to a diameter of about one eighth inch at the base. About 150 holes are made in each cheese. This favors the development of the penicillium throughout the interior of the cheese. Well-made cheese may be kept for a year or longer. In the region where made, much of the cheese is consumed while in a fresh condition.

Gruyère. This name is applied to Emmental cheese manufactured in France, the name originating from the Swiss village of Gruyère. The cheese was first mentioned in 1722, when two societies were reported to have been organized for its manufacture. The Gruyère cheese is made in three different qualities — whole milk, partly skimmed, and skimmed. It is usually made from partly skimmed milk, and this is supposed to distinguish it from Emmental, which is supposed to be made from whole milk. The manufacture of Gruyère cheese is an extensive industry in France, about 50,000,000 pounds having been manufactured annually the latter part of the last century.

Limburg. This is a soft rennet cheese made from cows' milk which may contain all of the fat or be partly or entirely skimmed. The best Limburg is undoubtedly made from whole milk. This cheese has a very strong and characteristic odor and taste. The cheese is about 6 by 6 by 3 inches and weighs about 2 pounds.

Limburg cheese originated in the province of Luttich, Belgium, in the neighborhood of Hervé, and was marketed in Limburg, Belgium. Its manufacture has spread to Germany and Austria, where it is very popular, and to the United States, where large quantities are made, mostly in New York and Wisconsin.

According to Doane and Lawson no Limburg is imported into

this country at the present time, this type of cheese being made so cheaply and of such good quality in this country that the foreign make has been crowded out of the market.

Neufchâtel. This is a soft rennet cheese made extensively in the Department of Seine-Inférieure, France, from cows' milk either whole or skimmed.

The milk, preferably fresh, is set at 85° F. with only so much rennet as is necessary to secure the desired coagulation in twenty-four hours in summer and from thirty-six to forty-eight hours in winter. The curd is then inclosed in cheesecloth and drained for twelve hours, after which it is subjected to pressure for another period of twelve hours. It is then thoroughly kneaded by hand, or in the larger factories by means of a curd mill, and pressed into tin cylinders about 2 inches in diameter and 3 inches high. The cheeses are removed soon from the molds, salted, and replaced. After draining for twenty-four hours they are transferred to the so-called "drying room," where they become covered with white and later with blue molds. They are then taken to the curing cellar, where the ripening process is continued for three to four weeks. The appearance of red spots on the surface is taken as an indication that the ripening has progressed far enough. The cheeses are then wrapped in tin foil and marketed.

Parmesan. This name is in common use outside of Italy for the cheese made and known in that country for centuries as Grana, the term "grana" or "granona" referring to the granular appearance of the cheese when broken, as is necessary on account of the hardness of the cheese, which makes cutting practically impossible. There are two quite distinct varieties of Parmesan cheese, one made in Lombardy and the other in Emilia, the centers of production being separated by the River Po. Parma, situated in Emilia, has long been an important commercial center for both varieties, and to this fact the name Parmesan is due. The use of the term "Parmesan," however,

is sometimes restricted to the cheese made in Lombardy, the term "Reggian" being used to designate that made in Emilia.

The Lombardy cheese made from April to September is known locally as *Sorte Maggenga* and that from October to March as *Sorte Vermenga*. The Reggian cheese is made only in summer.

Parmesan cheese when well made may be broken and grated easily and may be kept for an indefinite number of years. It is grated and used largely for soups and with macaroni. A considerable quantity of this cheese is imported into this country and sells for a high price.

Pineapple. This cheese, which is said to have had its origin in Litchfield County, Conn., about 1845, is so named from the fruit which the cheese is made to resemble in shape. It is a hard rennet cheese made from whole cows' milk. The cheese is quite hard and is rather highly colored. The early process of manufacture is the same as with Cheddar, except that it is made much harder. The curd is pressed in the desired shape in various sizes up to 6 pounds in weight. After pressing, the cheese is dipped for a few minutes in water at 120° F. and is then put in a net for twenty-four hours, which gives it the diamond-shaped corrugations on the surface. It requires several months to ripen and during this time the surface is rubbed with oil, which makes it very smooth and hard.

Roquefort. This is a hard rennet cheese made from the milk of sheep. There are, however, numerous imitations or varieties closely resembling Roquefort, such as Gex and Septmoncel, made from cows' milk. One of the most striking characteristics of this cheese is the mottled or marbled appearance of the interior, due to the development of a penicillium, which is the principal ripening agent. The manufacture of Roquefort cheese has been carried on in the southeastern part of France for at least two centuries. The industry is particularly important in the Department of Aveyron, in which is situated the village of Roquefort, from which the cheese derives its name. It is

also made in Corsica. Imitations of Roquefort cheese are made in various countries.

Formerly the manufacture of the cheese was carried on by the shepherds themselves, but in recent years centralized factories have been established and much of the milk is collected and there made into cheese. The cheese is then taken to the caves. These are for the most part natural caverns which exist in large numbers in the region of Roquefort and the air circulates freely through them. Recently, artificial caves have been constructed and used. When the cheeses reach the caves they are salted, which serves to check the growth of the mold on the surface. One or two days later they are rubbed vigorously with cloth and are afterwards subjected to thorough scraping with knives, a process formerly done by hand, but now much more satisfactorily and economically by machinery. The salting, scraping, or brushing seems to check the development of mold on the surface. In order to favor the growth of mold in the interior, the cheese is pierced by machinery with 60 to 100 small steel needles, which process permits the free access of air. The cheese may be sold after thirty to forty days or may remain in the caves as long as five months, depending upon the degree of ripening desired. The cheese loses during ripening by scraping and evaporation as much as 25 per cent of the original weight. The weight when ripened is about $4\frac{1}{2}$ to 5 pounds.

Stilton. This is a hard rennet cheese, the best of which is made from cows' milk to which a portion of cream has been added. It was first made near the village of Stilton, Huntingdonshire, England, about the middle of the eighteenth century. It is now made principally in Leicestershire and West Rutlandshire, though its manufacture has extended to other parts of England. Its manufacture has been tried, though without success, in the United States. The cheese is about 7 inches in diameter and 9 inches high, and weighs 12 to 15 pounds. It has a very characteristic wrinkled or ridged skin or rind, which is

likely caused by the drying of molds and bacteria on the surface. When cut it shows blue or green portions of mold which give its characteristic piquant flavor. The price in this country is about 45 cents a pound wholesale. The cheese belongs to the same group as the Roquefort of France and the Gorgonzola of Italy.

Relation of Microorganisms to Cheesemaking

That there should be hundreds of varieties of cheese all made from milk, rennet, and salt, but each having a characteristic flavor, is chiefly due to the differences in the microorganisms which take part in the ripening of the different varieties.

As a rule in the hard cheeses the ripening agents are distributed throughout the cheese mass at the beginning of the ripening process and therefore act in a more or less uniform way throughout the cheese whatever its size; while in the soft cheeses the ripening process is largely due to organisms growing on the surface and producing products which only gradually penetrate the cheese mass, so that it is practically necessary that these cheeses be made in small sizes.

It will be recalled from the above description of Cheddar cheesemaking that lactic acid bacteria are active in the ripening of the milk before curdling, in the whey and curd during the cheesemaking process, and in the ripening cheese. According to Hastings¹ the maximum number of bacteria is found when the cheese is one to five days old and may be as high as 1,500,000,000 per gram of moist cheese. While no one species is considered entirely responsible for this lactic acid fermentation, it is essential that the desirable types producing a clean lactic acid fermentation without gas production shall predominate over the undesirable gas-producing types.

During the ripening process the number of active lactic acid bacteria becomes considerably reduced and it is believed that

¹ Marshall's *Microbiology*, page 354.

the substances liberated in disintegration of these bacteria may play a part in the development of the characteristic flavor.

Emmental cheese ("Swiss" or "Schweitzer" cheese) differs from Cheddar cheese in that the lactic acid fermentation is much less pronounced during the process of making the cheese, while the fermentation during the ripening process is of a somewhat different type and gives rise to a different flavor. Lactic acid bacteria produce lactic acid or lactates which in turn are attacked by organisms of a different type with the production of carbon dioxide to which the characteristic holes or "eyes" are due.

Roquefort cheese owes its mottled appearance and much at least of its characteristic flavor to the growth of a mold, *Penicillium roqueforti* (Thom), which is introduced by sprinkling the curd with crumbs of bread on which this mold has grown. The growth of the mold in the cheese is favored by punching holes to admit the air.

Gorgonzola and Stilton cheeses resemble Roquefort and are supposed to contain either the same mold or a related type, *Penicillium glaucum*.

Camembert cheese owes its characteristic flavor and consistency chiefly to the growth of two molds, *Oidium* (*Oöspora*) *lactis*, which covers the cheese during the first few days of ripening, and *Penicillium camemberti*, which appears later. These molds utilize organic acids as food, thus reducing the acidity of the cheese, while they produce proteolytic (protein-digesting) enzymes which gradually penetrate and soften the cheese. The reduction of acidity, however, also renders the cheese more susceptible to attack by putrefactive bacteria which, if allowed to multiply in the cheese, will soon change its flavor. The manufacture of Camembert cheese is particularly difficult because the development of the desired consistency and flavor depends upon such a close control of conditions as will maintain a deli-

cate balance in the development of the different organisms involved.

Brie also owes its flavor and consistency to molds, while the red coloration of the surface is attributed to a bacillus.

Limburg cheese is characteristic of the type in which development of putrefactive bacteria is allowed to continue to a considerable extent with a corresponding development of putrefactive odor.

These statements regarding the rôle of microörganisms in cheese ripening are based largely upon Marshall's *Microbiology*, pages 354-362, and Buchanan's *Household Bacteriology*, pages 297-301, which works, as well as the more special papers listed in the bibliography at the end of this chapter, may be consulted for more detailed discussions.

Commercial Quality

The commercial quality of cheese depends upon the flavor, texture, body, color, and "appearance." By flavor is meant the quality which is perceptible to the taste and smell. "Texture" refers chiefly to compactness or appearance of solidity. "Body" means the consistency or firmness as revealed by pressing a piece of the cheese between finger and thumb. Color should be uniform whether the cheese is artificially colored or not. "Appearance" as the term is here used applies to the exterior finish of the cheese and its package.

The technical terms used in describing these qualities, together with other practices relating to the commercial grading and scoring of cheese, are described and explained in Van Slyke and Publow's *Science and Practice of Cheese-making*, Chapter VIII.

The following are typical scales of points used in judging and scoring cheese:

	EXPORT CHEESE	HOME-TRADE CHEESE
Flavor	45	50
Texture	15	25
Body	15	
Color	15	
Appearance	10	10

Composition, Adulteration, Standards of Purity

Qualitative composition. As is readily seen from its method of manufacture, cheese contains the casein and fat of the milk and so much of whey as does not drain out of the curd. The retention of portions of whey will of course keep in the cheese appreciable but small amounts of lactalbumin, of the soluble salts of the milk, and of milk sugar or the lactic acid resulting from its fermentation.

Quantitative composition. The composition of the milk and the details of manipulation in the manufacture of the cheese naturally influence the composition of the product. In a series of analyses covering 156 samples of green cheese of the Cheddar type made in various factories in New York State in 1892-1893, Van Slyke found: moisture, 32.7 to 43.9 per cent; fat, 30.0 to 36.8 per cent; protein, 20.8 to 26.1 per cent. Samples from more widely scattered sources would doubtless show greater variation. The approximate average composition of the principal types of cheese is shown in Table 6.

Except that the soft cheeses like Brie, Camembert, and Neuf-châtel are wetter and the hard pineapple cheese is dryer, it will be seen that the different varieties do not differ greatly from an average composition of about one third water, one third fat, and one fourth protein. These statements, of course, relate to whole milk cheese.

The fat of cheese, while not so perfectly emulsified as it origi-

nally existed in the milk, is still in a finely divided state and should be quite uniformly distributed throughout the cheese-mass. Chemically it has the composition of milk fat or butter fat and shows but little change as the result of the ripening process.

TABLE 6. APPROXIMATE AVERAGE COMPOSITION OF DIFFERENT TYPES OF CHEESE ¹

VARIETY	WATER	FAT	PROTEIN (N X 6.25)	SALT, MILK SUGAR, LACTIC ACID, AND ASH
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Brie . . .	50.	28.	18.	4.
Camembert .	45.	30.	20.	5.
Cheddar . .	35.	34.	25.	6.
Edam . . .	33.	29.	29.	9.
Emmental .	34.	31.	30.	5.
Limburg . .	35.	30.	29.	6.
Neufchâtel .	50.	27.	18.	5.
Parmesan .	35.	21.	36.	8.
Pineapple .	24.	38.	30.	8.
Roquefort .	35.	32.	25.	8.
Stilton . .	33.	37.	25.	5.

The protein of cheese consists chiefly of the more or less digested casein (though to a small extent of the albumin also) of the milk. It has already been shown in the paragraph on the ripening process that much of the casein is digested, not only into a soluble protein, but to proteoses, peptones, and even amino acids and ammonia. Of the successive analyses shown in Table 5, the one made when the cheese was six months old most nearly represents the stage of digestion at which it is ordinarily sold and eaten.

The ash of cheese varies greatly in composition according as much or little salt has been added during manufacture. It is

¹Based on analyses given in Bulletin 105, Bureau of Animal Industry, United States Department of Agriculture.

always high in calcium, phosphorus, and sulphur, and fairly high in iron, these elements of the milk being largely constituents of the curd; while the potassium, sodium, and chlorine of the milk are largely removed in the whey, but the sodium and chlorine are later more than restored in the added salt.

Adulteration and misbranding. The chief forms of adulteration and misbranding of cheese are deficiency (or substitution) of fat, excess of moisture, and misuse of geographical names. Cheese made from milk which has been wholly or partially skimmed is known as "skimmed milk cheese" or "skim cheese." This is a wholesome and nutritious food, but less palatable and of much less fuel value than whole milk cheese. Unless its sale is carefully regulated it is apt to be substituted to a greater or less extent for whole milk cheese, at least in retail trade, which is considered serious both as an imposition upon the consumer and as an injury to the cheese trade. Van Slyke and Publow point out that skim-milk cheese is not only deficient in fat but must also contain an excess of water in order to be salable, since a skim-milk cheese with only the same amount of water as a whole-milk cheese would be too hard and tough to be acceptable, and that because of this high moisture content it does not possess the keeping qualities of whole-milk cheese. They suggest that the sale of skim-milk cheese should be prohibited in the interest of the cheese industry. In many localities the restrictions placed upon skimmed milk cheese are in fact so stringent that it is practically driven out of the market.

Cheese made from skimmed milk and added fat is called "filled cheese." The trade in this cheese is also subjected to restrictions which are very nearly prohibitive. The United States cheese law requires that filled cheese shall be packed only in wooden containers which must be very conspicuously branded with the words "filled cheese" in several places, and retailers must sell only from these original packages and must deliver each portion of such cheese sold in a marked and branded pack-

age. (See Wing's *Milk and Its Products*, pages 382-387, where the full text of the law is given.)

Sometimes the cheese curd is soaked in cold water before the final draining, salting, and pressing. This practice is declared fraudulent by the Board of Food and Drug Inspection (Food Inspection Decision 97) on the ground that it introduces an undue amount of water into the cheese and also gives it a soft texture and an appearance of superior quality which deceives the purchaser as to its real nature. The Board further states that such cheese is of inferior quality in that it develops less of the desirable cheese flavor and that it deteriorates during the curing process, and therefore rules that such cheese may not enter interstate commerce unless under some such name as "soaked curd cheese."

Standards of purity. According to the definitions and standards recommended by the Association of Official Agricultural Chemists:

Cheese is the sound, solid, and ripened product made from milk or cream by coagulating the casein thereof with rennet or lactic acid, with or without the addition of ripening ferments and seasoning, and contains, in the water-free substance, not less than 50 per cent of milk fat. By act of Congress, approved June 6, 1896, cheese may also contain added coloring matter.

It will be noted that this standard sets no specific limit to the water content, but requires that the fat in the cheese shall be milk fat and shall constitute not less than 50 per cent of the total solids of the cheese. (Cheese with a lower fat content may be sold as skimmed milk cheese.)

This is based on the proportions of fat and casein in whole milk and on analyses of cheese made by the New York State Experiment Station in coöperation with cheesemakers of the state and in Wisconsin in connection with a cheese-scoring contest.

In the New York analyses the percentage of fat in the water-

free substance varied from 50.39 to 56.83; in the Wisconsin analyses from 51.35 to 56.4.

Evidently therefore the requirement that 50 per cent of the solids shall be fat sets a high standard and assumes not only the use of normal milk but also skillful making of cheese to avoid loss of fat.

Minnesota has a standard calling for 45 per cent fat in the solids of cheese. Colorado requires only 35 per cent. Missouri requires that cheese be made of milk having at least 3 per cent fat. In Ohio any cheese having less than 20 per cent fat (in the moist substance) must be sold as skimmed milk cheese.

Van Slyke estimates that cheese made from normal whole milk rarely contains less than 32 per cent fat in the moist substance, even when green.

Nutritive Value and Place in the Diet

A pound of cheese represents the casein and fat of a gallon of average milk. The high nutritive value of casein has been explained in the preceding chapter. Cheese is thus a concentrated and economical food, especially when compared with other foods of animal origin.

Generally speaking cheese sells at no higher price per pound than the ordinary cuts of meat, while it is considerably richer in both proteins and fat.

While fluctuations in price and in the proportions of fat and bone in the meats make exact comparisons impracticable except for individual cases, yet it is a fair general estimate that a given amount of money spent for American cheese at ordinary prices will buy about twice as much food value as it would if spent for meat. In most localities cheese gives a greater return in food value for the money expended than other staple foods of animal origin, but in some places milk may be obtained at such prices as to make it a cheaper food than cheese.

Cheese is very rich, not only in protein and fat, but also in

calcium and phosphorus, since these elements in milk are largely in combination in or with the casein and so are concentrated with the casein in the process of cheesemaking. The iron-protein compounds of the milk are also retained in the cheese.

Digestibility of cheese. The discomfort which sometimes follows the eating of cheese may be due in part to irritation of the stomach by the volatile acids and some of the protein cleavage products developed during the ripening, but is doubtless very largely attributable to the unsuitable way in which cheese is often eaten — as at hours other than meal times or at the end of a meal already sufficient. When given a rational place in the meal, and thoroughly chewed, cheese is usually well digested. In a large number of digestion experiments carried out by the United States Department of Agriculture, it was found that on an average about 95 per cent of the protein and over 95 per cent of the fat of the cheese were digested and absorbed.¹ Hence so far as the coefficients of digestibility are concerned the various kinds of cheese tested were found to compare favorably with the average food of an ordinary mixed diet. Even when fed in relatively large quantity the cheese did not, in these experiments, cause constipation “or other physiological disturbances.”

The general belief that cheese is difficult of digestion is attributed by Langworthy to its being digested to a less extent in the stomach than many other foods, the digestion of the cheese taking place chiefly in the intestine. In order to determine whether the digestion of cheese requires a greater expenditure of energy than the digestion of meat, Langworthy measured accurately by means of the respiration calorimeter² the energy metabolism of the same man after eating a meal consisting chiefly of beef and again under circumstances otherwise the same after eating a meal containing instead of the beef a corresponding amount of cheese. The results differed by only 2 Calories per

¹ *Yearbook of the United States Department of Agriculture*, 1910, page 366.

² Described in *Chemistry of Food and Nutrition*, Chapter V.

hour, which is about the margin which must be allowed for experimental error in such measurements. Langworthy therefore concludes that "it seems fair to believe that there was practically no difference between the cheese and the meat with respect to ease of digestion, at least in such quantities as are commonly eaten."

Place of cheese in the diet. Langworthy records a case of a young man who "for the sake of such considerations as ease of preparation and relative economy" lived for over two years on a diet of cheese, bread, and fruit. The man enjoyed good health and did not tire of his diet. A quantitative record covering a part of the time indicated that the man was accustomed to consume slightly over one half pound of cheese, one pound of whole wheat bread, and two pounds of fresh fruit per day.

The amounts of cheese eaten by the various men who took part in the experiments of the United States Department of Agriculture were usually from one third to one half pound per day. These quantities were taken with relish and were well digested even though the men as a rule had previously not been accustomed to eat any considerable quantity of cheese.

The bulletin by Langworthy and Hunt already referred to contains many specific suggestions for the use of cheese in a variety of ways and includes the following conclusions:

Experiments have shown that when eaten either raw or carefully cooked, cheese is as thoroughly digested as other staple foods and is not likely to produce physiological disturbance.

The fact that cheese, like meat, contains neither starch nor cellulose suggests that, like meat, it should be combined with bread, potatoes, and other starchy foods, with vegetables and with sweets. The concentrated character of cheese and many cheese dishes suggests the use of succulent fruits and vegetables with them. The high percentage of fat in cheese suggests the use of correspondingly small amounts of fat in the accompanying dishes, while the soft texture of cheese dishes as compared with meat makes it reasonable to serve the harder and crustier breads with them.

Though cheese is so generally used in some way in most families, yet the making of menus with cheese as a central dish is less well understood than more usual food combinations, since there is less experience to serve as a guide. More thought is therefore usually required to arrange such cheese meals in order that they may be palatable and at the same time reasonable in nutritive value.

In order that the diet may remain well balanced, cheese, if used in quantity, should replace foods of similar composition rather than supplement them.

This means that the housekeeper, in suitable ways, can use cheese, meat, fish, eggs, and other foods of similar composition as substitutes for one another, being governed by their relative market value at different times and seasons, by the tastes of her family, and similar considerations. If she uses the different foodstuffs with reference to their nutritive value and is skillful in preparing foods in appetizing ways and in serving them in attractive combinations, the daily fare may be both adequate and pleasing, whether she selects cheese or meat or fish or eggs or other foods to supply nitrogenous material and fat.

As already suggested, cheese should be eaten with intelligence to avoid danger of irritation of the stomach, and a warning may also be added against eating large quantities at a time of cheese which has been so highly ripened as to contain a considerable percentage of ammonia. With these precautions cheese may well be used as a regular staple article of food, interchangeably with such foods as meats and fish. As the food value and digestibility of cheese become better known it should come to occupy a much more prominent place in the typical dietary than it does at present.

Fermented Milks

We have seen that the making of cheese is a very old method of preserving milk for future use as food. Another old method, yielding a product less permanent than cheese, but more permanent than fresh milk, is to allow the milk to undergo fermentation of such a character that the fermentation products are not unwholesome or unpleasant for human consumption, yet serve as preservatives to prevent undesirable types of decomposition.

The fermentation product chiefly depended upon in such cases is lactic acid, although in certain types alcoholic fermentation may also be prominent. Fermented milks have long been a prominent article of diet in Southern Russia, Turkey, Bulgaria, and neighboring countries, and in recent years various products of this type such as kumiss, kefir, yoghurt, and fermented milks sold under proprietary names have come into increasing use in Western Europe and in America.

Buttermilk is a food of the same type, and until recently the demand for fermented milk in this country was readily met by the sale of a part of this by-product of buttermaking. As the manufacture of butter and the handling of market milk and cream grew to be separate industries, dealers in milk and cream sometimes met the demand for buttermilk by fermenting the skim milk which remains as a by-product of the cream trade. Such fermented skim milk is, of course, not literally buttermilk, although it may be indistinguishable in composition and properties and equal in food value.

On the other hand, the products made by fermenting whole milk are of considerably greater food value because of their higher fat content.

It is, however, not simply because of the amounts of nutrients which they contain that these fermented milks have attracted special attention in recent years, but because of belief that the finely coagulated casein of these preparations is more easily digested than the curds which are formed in the stomach after drinking ordinary milk, and especially because of the possible therapeutic or prophylactic value of the lactic acid or lactic acid bacteria which they contain.

In some cases it is possible that the fermentation products (lactic acid, alcohol, carbonic acid) may have a slight stimulating or tonic action in the digestive tract; otherwise any increased digestibility of the fermented milk is due not so much to changes in the chemical nature of the milk constituents as to

the fact that the casein is furnished in a precipitated and finely divided condition. The fermentation does not involve any material digestive cleavage of the casein such as occurs in the ripening of cheese. The fat is almost unchanged and only a part of the milk sugar is converted into organic acids, alcohol, and carbonic acid. In certain disorders of the stomach in which there is much difficulty in retaining food, it has frequently been found possible to use one or another of the fermented milks with good results. As the result of the studies of Metchnikoff and his associates at the Pasteur Institute in Paris, there has recently been much interest in fermented milks as a possible means of preventing or controlling excessive intestinal putrefaction. It is for this purpose that cultures supposed to give a purer lactic acid fermentation than that of buttermilk have been introduced. In buttermilk or in ordinary milk which has been allowed to sour freely, there is usually developed only about 1 per cent of lactic acid; but certain selected species of lactic acid bacteria, notably *B. bulgaricus*, may carry the fermentation to such a point that the milk may contain 2 per cent of lactic acid or even more.

The use of fermented milk in combating the putrefactive bacteria of the large intestine is based on the theory that the introduction of lactic acid bacteria or of lactic acid itself into the intestine makes the conditions unfavorable for the putrefactive bacteria. The question therefore arises whether the lactic acid taken in the food reaches the large intestine in sufficient quantity to be effective or is absorbed from the small intestine, and whether it is possible to establish a predominance of lactic acid bacteria in the intestinal tract by taking rich cultures of such bacteria in the food. The evidence on these points is conflicting, some observers reporting much diminution of intestinal putrefaction as the result of drinking fermented milk, while others find little if any effect. Herter held that the total amount of protein in the food is an important factor in the problem and

that the *mere addition* of fermented milk to the diet may do as much harm as good through making the total amount of protein excessive, whereas improvement may result if the fermented milk is *substituted* for some high-protein food so that the total protein eaten is either kept constant or diminished.

The evidence at present available leaves the therapeutic value of fermented milks somewhat uncertain, but there is no doubt that they are valuable foods especially for those who either relish or digest the fermented milk better than the unfermented. The advantages of milk as a food (see latter part of last chapter) apply in general to fermented milk also.

Some representative analyses of fermented milks are given in Table 7.

TABLE 7. ANALYSES OF SOME FERMENTED MILKS

	BUTTERMILK (LARSEN AND WHITE)	KUMISS OR KEFIR (HAMMARSTEN)		
		2 days old	4 days old	6 days old
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Water . . .	90.39	88.12	88.79	89.00
Fat	0.50	3.62	3.63	3.63
Protein . .	3.60	3.03	3.07	3.07
Milk Sugar .	4.06	3.70	2.24	1.67
Lactic Acid .	0.80	0.66	0.83	0.90
Alcohol . .		0.23	0.81	1.10
Ash	0.75	0.64	0.63	0.63

Evaporated or Condensed Milk

By evaporating a large proportion of the water from milk, the keeping property is much improved and the labor and expense of subsequent handling and transportation of the product are further reduced through the saving in bulk and weight. Sugar is often added as a preservative. Condensed milk, whether sweetened or unsweetened, may be marketed in bottles like ordinary milk, in which case it is intended for use within a very

few days, or it may be sealed in tin cans for indefinite keeping like other canned foods.

The condensed milk industry began with the granting of a patent for "concentrating sweet milk by evaporation in vacuo" to Gail Borden, Jr., in 1856. In 1880 the total production (United States Census) in the United States was 13,033,267 pounds valued at \$1,547,588; in 1890, 37,926,821 pounds valued at \$3,586,927; in 1900, 186,921,787 pounds valued at \$11,888,792; in 1909, 494,796,544 pounds valued at \$33,563,129. It is evident that the industry is growing very rapidly and the present production is doubtless much above that of 1909. The census returns for that year show about equal amounts of the sweetened and the unsweetened product.

Sweetened condensed milk is manufactured by a carefully regulated process which in brief outline may be described as follows: Fresh cows' milk is heated to 160° to 180° F. to expel the dissolved gases and then run into vacuum pans, about 16 pounds of sugar per 100 pounds of fresh milk is added, and the mixture evaporated in vacuo at a temperature of 130° to 150° F. until the desired concentration is reached, usually until one pound of the final product represents about $2\frac{1}{4}$ to $2\frac{1}{2}$ pounds of fresh milk. This final product is of semiliquid consistency with a specific gravity of about 1.29 and averages about 30 per cent water, 30 per cent milk solids, and 40 per cent cane sugar.

The products of individual manufactures may vary considerably from this average. In 24 analyses compiled by the United States Department of Agriculture,¹ the variations were as follows: water 21.6 to 37.3, average 26.9 per cent; protein 6.0 to 10.5, average 8.8 per cent; fat 0.4 to 10.6, average 8.3 per cent; carbohydrates, 44.4 to 56.9, average 54.1 per cent; ash. 1.5 to 2.1, average 1.9 per cent. Here the most noticeable variation is in the fat content, due to the fact that some of the analyses represent the product obtained from milk which had

¹ Bulletin 28, Office of Experiment Stations.

previously been skimmed. Under present regulations such a product must be labeled "condensed skim milk" to avoid confusion with the whole milk product. The latter has been standardized by the Association of Official Agricultural Chemists as follows:

"*Sweetened condensed milk* is milk from which a considerable portion of water has been evaporated and to which sugar (sucrose) has been added, and contains not less than 28 per cent of milk solids of which not less than 27.5 per cent is milk fat."

(*Note.* Twenty-seven and five tenths per cent of twenty-eight per cent equals seven and seven tenths per cent of fat in the condensed milk.)

Unsweetened condensed milk, commonly called *evaporated milk*, is prepared in essentially the same manner as described under sweetened condensed milk above, except that no sugar is added, the ratio of concentration is usually slightly less, and the final product, after sealing in cans, is sometimes sterilized by heating at 226° F. to 240° F. for from 30 to 60 minutes. The final product has a creamy consistency and a specific gravity of about 1.065. According to the standards recommended by the Association of Official Agricultural Chemists in 1906, it must contain not less than 28 per cent of milk solids with a minimum of 7.7 per cent fat.

More recently,¹ as the result of further study, the Board of Food and Drug Inspection has revised the requirement, raising the fat standard slightly and allowing a somewhat lower degree of concentration, and therefore somewhat lower percentage of solids-not-fat, in the case of milk having more than the required amount of fat. This is accomplished by requirement that the percentage of fat shall be not less than 7.8, and the sum of the percentages of total solids and fat shall be not less than 34.3. In the same decision it was specified that evaporated milk should be prepared from milk of good quality and contain no added

¹ Food Inspection Decision 131.

butter or butter oil incorporated either with the whole or skimmed milk before evaporation or with the evaporated milk at any stage of manufacture.

To make 100 pounds of evaporated milk which shall meet the requirements of the Board of Food and Drug Inspection, in solids and fat, will require 240 pounds of milk which contains 3.25 per cent of fat and 8.5 per cent of other solids, or 204 pounds of milk containing 4 per cent of fat and 8.9 per cent of other solids.

Whether the evaporated milk can be sold at retail at a price which makes it more economical to the consumer than an equivalent amount of fresh milk of corresponding sanitary quality will depend upon local conditions. In the markets of the large cities at present (and naturally to a still greater extent in the small towns of the agricultural regions) the fresh milk appears to be more economical for the retail consumer. In markets at a distance from dairy districts the economic advantage will more often lie with the evaporated product. The fact that evaporated milk is less perishable than fresh milk is a decided advantage to purchasers who use milk for the manufacture of other products for which there is a fluctuating demand, such as ice cream and special bakery products.

Dried or Powdered Milk

Several processes have been invented for reducing milk to the form of a dry powder. The advantages of this are of course the great saving in bulk and weight and the fact that the powdered milk is even less subject to contamination or deterioration than evaporated or condensed milk. Among the devices for drying milk on a commercial scale are: (1) passing the milk in thin layers over heated surfaces preferably in vacuo, (2) blowing air through layers of milk which have been partially evaporated on perforated drying cylinders, (3) spraying partially

evaporated milk into warm, dry air. The latter process as described by Merrill¹ is in outline as follows:

Fresh whole milk is partially evaporated in a vacuum pan with precautions to prevent any of the albumin from coagulating on the walls of the chamber. The milk, still in a fluid condition, is then drawn from the vacuum pan and sprayed into a current of hot air. The remaining moisture is thus instantly evaporated and the particles of milk solids fall like snow. This milk powder is said to contain less than 2 per cent moisture and to consist of particles from $\frac{1}{2000}$ to $\frac{1}{10000}$ inch in diameter, in which the fat, sugar, and albumin of the milk exist in a dry state, chemically unchanged.

This process appears to be well established commercially, the product being purchased largely by bakers.

According to data published by Wells in the Yearbook of the United States Department of Agriculture, there had already, in 1911, been granted over 60 patents covering devices for the manufacture of dried milk, and 10 factories were engaged in carrying on the industry in the United States. It was estimated that about 8,500,000 pounds of milk powder were made in this country in 1910. Most of this was skim milk powder, because legal restrictions hamper the sale of skim milk as such to the consumer, while on the other hand it is more easily dried than whole milk and yields a product which is more readily kept, the fat of the whole milk powder being liable to become rancid on storage unless kept under special precautions.

It is believed that the industry of drying both whole and skimmed milk has grown much since the above statistics were collected and is still growing rapidly.

Cream

Cream may be obtained from milk either by gravity or by centrifugal force. The prevailing method at present is by means

¹ *Journal of Industrial and Engineering Chemistry*, August, 1909.

of centrifugal separators in which the milk flows continuously into a rotating bowl containing thin metal plates which separate the milk into inclined sheets in which by centrifugal force the heavier "skim" milk is thrown toward the outer rim¹ and the lighter fat globules are forced toward the center. Thus while the separator is in operation a continuous stream of cream and another of skimmed milk are obtained from the inner and outer layers respectively of the rotated bowl of milk. In order that the skimmed milk shall not be thrown out of the machine with too great force, the tubes which receive it from the outer portion of the bowl are carried back toward the center of the bowl where they discharge into an outlet pipe. The size of the skim milk outlet may be made to bear any desired relation to the size of inlet, size of bowl, and speed of rotation, and thus any desired proportion of the whole milk may be drawn off as skimmed milk while the remainder is forced to the center of the bowl and discharged through the cream outlet.

If the skimmed milk outlet is set to discharge only one half of the milk entering the bowl, the other half must discharge through the cream pipe and a large volume of very thin cream having only twice the fat content of the original milk will be obtained.

If the skimmed milk tube be set to take nine tenths of the amount of milk which flows in, a small amount of rich cream having about ten times the fat content of the original milk will result.

To a considerable extent these proportions and the resulting amount and richness of the cream may be controlled by regulating the rate of inflow of milk without changing the size of the discharge pipes or the rate of running the machine. Thus, as illustrated by Wing: "If the milk is turned into the bowl at such a rate that 0.8 escapes through the skimmed milk outlet,

¹ Suspended solids heavier than the skim milk are forced against the outer wall and result in a deposit of "separator slime."

we shall have 0.8 skimmed milk and 0.2 cream. If now we reduce the rate of inflow by 0.1, we shall get just as much skimmed milk as before, but only half as much cream; or if the inflow is increased by 0.1 we shall get the same amount of skimmed milk and one and one half times as much cream." In the first case, we should get from 100 pounds of milk with 4 per cent fat, 80 pounds of skimmed milk with, say, 0.1 per cent of fat, and 20 pounds of cream with 19.6 per cent fat; in the second case from 90 pounds of the same milk, 10 pounds of cream with 35.2 per cent fat; in the third case from 110 pounds of the same milk, 30 pounds of cream with 14.4 per cent of fat. This assumes that the completeness of the separation will be the same, which should be true so long as the separator is run within the range of its capacity. McKay and Larsen state that in skimming milk for buttermaking, separators are usually run to yield cream with 25 per cent to 50 per cent fat, but that most separators will do good skimming even up to a cream of 60 per cent fat content. When the separator is well managed, the skim milk does not contain over 0.1 per cent fat.

Since cream is an artificial product of such variable composition, it is obvious that any standard which may be set for the fat content of cream must necessarily be rather arbitrary. The standards which have been adopted appear to have been based largely on the fat content of the cream formerly obtained by the gravity process.

The standard recommended by the Association of Official Agricultural Chemists requires not less than 18 per cent of milk fat; and this has been adopted¹ by the states of California, Georgia, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maine, Maryland, Missouri, Nebraska, New Hampshire, New York, Nevada, North Carolina, Oklahoma, Pennsylvania,

¹ All these statements regarding state standards are based on Circular 218 (Revised) of the Bureau of Animal Industry, United States Department of Agriculture, dated November 1, 1913.

South Dakota, Utah, Virginia, Washington, Wisconsin, and Wyoming. Minnesota, Montana, Oregon, and the District of Columbia require 20 per cent fat; Colorado, Iowa, and New Jersey require 16 per cent; Massachusetts and North Dakota require 15 per cent of fat; Colorado and Kansas have standards of 25 per cent fat in cream for buttermaking.

Market cream is apt to be at least half a day older than the corresponding grade of market milk and almost invariably has a higher bacteria content.

The Commission on Milk Standards recommends that cream be classified on the same plan as milk except for the number of bacteria permitted, which may be five times the number permitted in the corresponding grade of milk.

The Commission recommended that all cream be sold either on a guaranteed fat content or with a minimum standard of 18 per cent milk fat; also that cream should contain no constituent foreign to normal milk.

Ice Cream and Related Products

According to the Vermont Agricultural Experiment Station, the output of the ice cream industry in the United States is valued at considerably more than \$100,000,000 annually. The ice cream trade has grown enormously in recent years and appears to be still increasing. Creameries which are favorably located find it often much more profitable to convert their cream into ice cream than into butter.

The term "ice cream" is commonly applied to a variety of products, including what would more accurately be called frozen custards and water ices. There is not yet a consensus of opinion among food control authorities as to whether the wider application of the term "ice cream" is justified by common usage or whether the narrower and more literal usage should be insisted upon.

The Association of Official Agricultural Chemists in 1906 proposed the following standards:

Ice cream is a frozen product made from cream and sugar, with or without a natural flavoring, and contains not less than 14 per cent of milk fat.

Fruit ice cream is a frozen product made from cream, sugar, and sound, clean, mature fruits, and contains not less than 12 per cent of milk fat.

Nut ice cream is a frozen product made from cream, sugar, and sound, non-rancid nuts and contains not less than 12 per cent of milk fat.

In 1911 the Board of Food and Drug Inspection ruled against the use of "homogenized" (finely divided by mechanical means) butter fat in making ice cream.

As yet there has not been any general tendency throughout the country to adopt and enforce these stringent standards. Neither is there yet any general agreement as to whether or to what extent such materials as starch, flour, eggs, gelatin, and gums should be permitted.

Those who desire to follow this subject further will find references at the end of this chapter. Special attention may be directed to Bulletin 155 of the Vermont Agricultural Experiment Station, in which the making of ice cream is discussed in detail, and to the article on ice cream standards by Wiley in Bulletin 56 of the United States Public Health Service, in which are discussed numerous trade practices which the standards above given were designed to control.

Until the matter of terminology and standards is more definitely settled, statements regarding the composition and food value of these products cannot be very definite. An ice cream which meets the standards of the Association of Official Agricultural Chemists is evidently a fairly concentrated food material, while many of the ices commonly called ice creams are essentially frozen beverages. Frozen products made from fermented

milk, sugar, eggs, and fruit, fruit juices, or other flavoring have recently been introduced under the general name of "lacto."

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CHAPTER V

EGGS

DOUBTLESS eggs of various kinds were among the very earliest of human foods. At the present time only the eggs of hens, ducks, geese, guinea fowl, and turkeys are commonly used for food; and of these, hens' eggs are so much more abundant than all others that, unless otherwise explained, all statements made here may be understood as referring to hens' eggs.

Production

The production of eggs is widely distributed. It is estimated that about nine tenths of all farms in the United States keep chickens and produce eggs. It will be seen from Fig. 7 that in poultry culture there is less tendency toward concentration in particular regions than is the case with many other food industries.

It is difficult to measure the egg production of the country, because eggs are so largely consumed by the producer or sold at retail without going through trade channels from which accurate statistics can be obtained. The United Census Bureau estimates the egg industry at seventeen and one half dozen eggs per capita per year, *i.e.* an average of 210 eggs per year or 4 eggs per week for each person in the United States. The value of these eggs (at point of production) is estimated by the Census Bureau at somewhat over \$300,000,000 annually (for the year 1909, \$306,689,000).

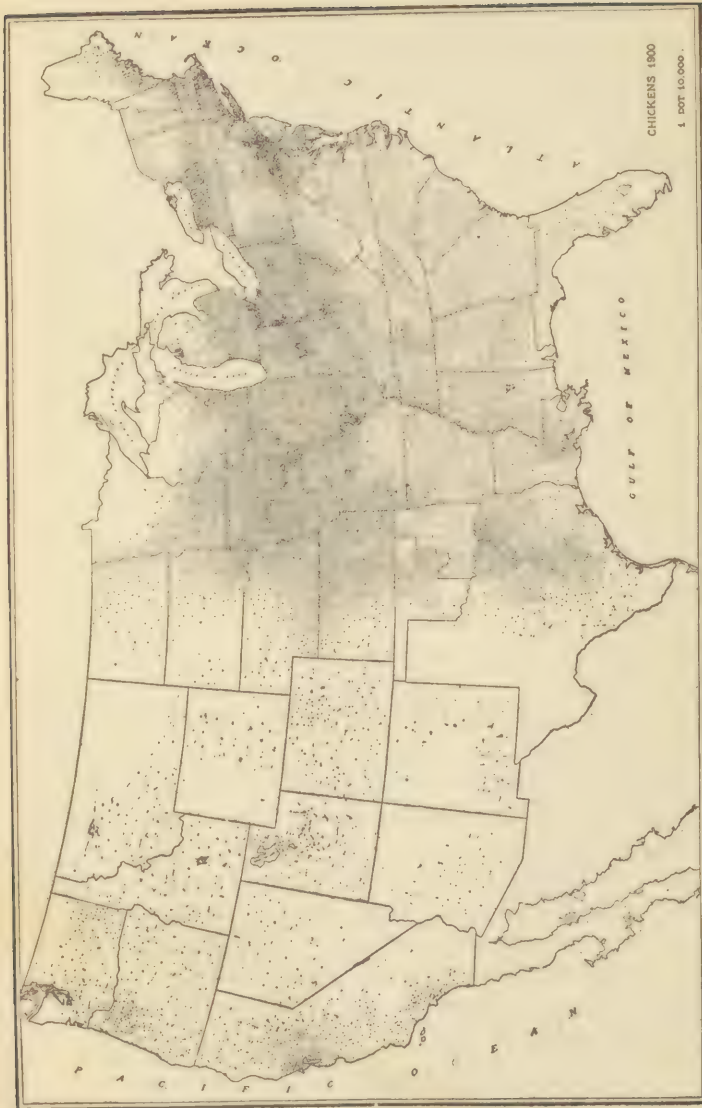


FIG. 7.— Distribution of chickens in the United States according to the census of 1900. Reproduced by permission from Taylor's *Prices of Farm Products* (Bulletin 209 of the Wisconsin Agricultural Experiment Station).

According to Pennington and Pierce ¹ only the States of Ohio, Indiana, Illinois, Iowa, Minnesota, Nebraska, Kansas, Missouri, Texas, Tennessee, and Kentucky produce more eggs than are consumed within their own borders, and this surplus production does not continue throughout the year, but only during those months which are most favorable to laying. From Tennessee and Kentucky most eggs are sent to market during the period from December to April; from Southern Ohio, southern Kansas, Missouri, and Texas many eggs are shipped during March and April; in the later spring northern Kansas, Iowa, Illinois, and the Central States generally show their heaviest production, while for Michigan and Minnesota the season is still later.

For the country as a whole, as judged by the data of the large markets, the months of March, April, May, and June are those in which the largest number of eggs are shipped by the producers. During these months many eggs are placed in cold storage to be sold later when the supply is less abundant and the price higher.

Eggs are graded in the market chiefly according to freshness, cleanliness, size, cracks, and color. Freshness in this connection means the firmness and state of preservation of the egg, rather than the mere length of time since laying. This freshness is determined chiefly by the process known as candling, which consists in looking through the egg against a bright light, such as an incandescent electric light, surrounded by an opaque shield in which is a hole shaped like an egg but slightly smaller in size. The egg is pressed firmly against this hole and, as the light shines through it, the yolk, the white, and the air-chamber may be observed. Figure 8 shows the appearance of a fresh sound egg and of eggs which have undergone different types of deterioration.

Eggs sufficiently sound to pass the candling test may still be subdivided into many grades according to age, color, size, and

¹ United States Department of Agriculture, Yearbook for 1910.

cleanliness. It is these qualities rather than chemical composition and nutritive value which determine the very different prices at which eggs are sold in the same market and at the same time.

Chemical Composition

Since the price of eggs is determined entirely by considerations other than chemical composition, and eggs are never produced primarily for industrial uses in which the components are separated from each other, there has been no economic reason for the study of the causes and extent of variations in composition, and our information on these points is very meager as compared, for example, with the corresponding data for milk. Differences in composition seem usually due to different proportions of white and yolk. According to Langworthy the proportion of yolk (and therefore of fat) is greatest in the eggs of those breeds which are best adapted to fattening. Other things being alike, the edible portion of white-shelled and dark-shelled eggs shows essentially the same composition and nutritive value.

The average composition of eggs of different kinds is given by Langworthy on page 132, the fuel values being recalculated by the use of the now accepted factors.

The figures given for hens' eggs in the following table are the average of 60 American analyses compiled by Atwater and Byrant¹ in which the protein varied from 11.6 to 16.0 per cent and the fat from 8.6 to 15.1 per cent. The estimated averages of European writers fall well within these limits, but are apt to be somewhat higher in fat than the American average as given above. Thus the estimate of König, which is widely quoted, allows 12.55 per cent protein and 12.11 per cent fat.

Speaking in round numbers we may say that the edible por-

¹ United States Department of Agriculture, Office of Experiment Stations, Bulletin 28.

TABLE 8. AVERAGE COMPOSITION OF EGGS (LANGWORTHY)

DESCRIPTION	REFUSE (SHELL)	WATER	PROTEIN	FAT	ASH	FUEL VALUE PER POUND
	Percent	Percent	Percent	Percent	Percent	Calories
Hen :						
Whole egg as purchased	11.2	65.5	11.9	9.3	0.9	596
Whole egg, edible portion		73.7	13.4	10.5	1.0	672
White		86.2	12.3	0.2	0.6	231
Yolk		49.5	15.7	33.3	1.1	1643
White-shelled eggs as purchased	10.7	65.6	11.8	10.8	0.6	655
Brown-shelled eggs as purchased	10.9	64.8	11.9	11.2	0.7	675
Duck :						
Whole egg as purchased	13.7	60.8	12.1	12.5	0.8	730
Whole egg, edible portion		70.5	13.3	14.5	1.0	835
White		87.0	11.1	0.03	0.8	203
Yolk		45.8	16.8	36.2	1.2	1683
Goose :						
Whole egg as purchased	14.2	59.7	12.9	12.3	0.9	737
Whole egg, edible portion		69.5	13.8	14.4	1.0	829
White		86.3	11.6	0.02	0.8	211
Yolk		44.1	17.3	36.2	1.3	1793
Turkey :						
Whole egg as purchased	13.8	63.5	12.2	9.7	0.8	618
Whole egg, edible portion		73.7	13.4	11.2	0.9	700
White		86.7	11.5	0.03	0.8	210
Yolk		48.3	17.4	32.9	1.2	1660
Guinea fowl :						
Whole egg as purchased	16.9	60.5	11.9	9.9	0.8	620
Whole egg, edible portion		72.8	13.5	12.0	0.9	735
White		86.6	11.6	0.03	0.8	212
Yolk		49.7	16.7	31.8	1.2	1598
Plover :						
Whole egg as purchased	9.6	67.3	9.7	10.6	0.9	609
Whole egg, edible portion		74.4	10.7	11.7	1.0	662
Fresh-water turtle eggs		65.0	18.1	11.1	2.9	772
Sea-turtle eggs		76.4	18.8	9.8	0.4	742
Salted duck eggs		68.0	12.0	9.2	4.0	594

tion of the egg contains 72 to 75 per cent of water, about 1 per cent of ash, 12 to 14 per cent protein, 10 to 12 per cent fat; or about three fourths water, one eighth protein, and one eighth fat. Of the edible portion the yolk constitutes (by weight) a little over one third and the white a little under two thirds; and these are of very different composition. The white is about seven eighths water and one eighth protein (chiefly albumin) with a small amount of ash, consisting mainly of common salt with smaller amounts of potassium salts. The yolk is about one half water, one third fat and one sixth protein with more ash than the white, including relatively large amounts of phosphorus, calcium, and iron in organic combination. Thus the yolk is a much more concentrated food material than the white, containing in a given weight about seven times as much energy, as well as larger amounts of protein and of the chief ash constituents.

The nature of the nutrients in eggs is of almost as much interest and importance as their amount. The fact that when an egg is kept at a proper temperature for about three weeks without the addition of anything from without, it produces a chick so well developed as to begin at once to walk and to eat the same food as the adult, suggests at once that the egg must contain substances which are very efficient as sources both of the energy and the materials for growth and development.

The fat of egg is practically all in the yolk, and like milk fat it exists in a finely emulsified condition, so that it is capable of digestion in the stomach as well as in the intestine. Volhard has reported an experiment in which 78 per cent of the fat of egg yolk was digested in the stomach. A large proportion of the egg fat, probably at least one fourth, consists of phosphorized fats (lecithins together with closely related substances, such as kephalins). Egg lecithin is usually taken as typical of the "phosphorized fats," "phospholipines," or "phosphatids." It has the chemical structure of a fat in which one of the fatty

acid radicles is replaced by a radicle of phosphoric acid in combination with a nitrogenous organic base (choline). The typical lecithin molecule thus contains one atom each of phosphorus and nitrogen; that described by Hoppe-Seyler had the composition $C_{44}H_{90}NPO_9$.

Studies of the loss of weight together with the amount of carbon dioxide produced during incubation show that the energy expended in the developing embryo comes chiefly from the utilization of fatty matter, and analyses at different stages of development indicate that lecithin plays an important part in the development of the chick. Such observations gave rise for a time to an exaggerated impression of the influence of lecithin upon growth. While we do not now expect to be able to produce abnormally large or rapid growth by lecithin feeding, there are reasons to believe that normal growth is dependent upon the presence of a certain amount of lecithin or related substance in the food, and that therefore the lecithin has a food value somewhat greater than that of a corresponding amount of simple fat and inorganic phosphate.

Recent investigations, especially those of McCullom and his associates at the Wisconsin Agricultural Experiment Station, appear to demonstrate that the nature of the fatty acids in both the ordinary fat and the phosphorized fat of the egg is influenced by the food of the hen. This is consistent with earlier observations relating to the influence of the food upon butter fat and upon the fat of the adipose tissues. (See *Chemistry of Food and Nutrition*, Chapter IV.)

Dissolved in the fat of the egg yolk is a yellow coloring matter to which the name lutein has been given.

The proteins of egg are also of much interest, and those of the yolk and of the white are quite different in their properties. The fact that egg white contains so little of any other substances than protein and water makes it easy to observe the behavior of the proteins. Egg white is therefore largely used as a material

with which to demonstrate the properties of proteins — particularly of the albumins, since ovalbumin is the chief protein of the egg white. According to Osborne and Campbell ¹ egg white also contains small quantities of three other proteins called conalbumin, ovomucin, and ovomucoid. The chemical constitution of these minor proteins has not been studied. Ovalbumin has been purified in quantity by Osborne, Jones, and Leavenworth, and studied with reference to the amino acids yielded on hydrolysis; the results together, with those for ovovitellin, are shown below.

Ovovitellin is the chief protein of the egg yolk. It is believed to exist largely in chemical combination with lecithin.² When freed from lecithin, it has nearly the composition of casein, as shown by the following analyses:

	CARBON	HYDROGEN	NITROGEN	OXYGEN	SULPHUR	PHOSPHORUS
	<i>Per Cent</i>	<i>Per Cent</i>	<i>Per Cent</i>	<i>Per Cent</i>	<i>Per Cent</i>	<i>Per Cent</i>
Casein	53.13	7.06	15.78	22.37	0.80	0.86
Ovovitellin	51.56	7.12	16.23	23.24	1.03	0.82

Casein and ovovitellin are regarded as the two typical phosphoproteins.

The percentages of the various amino acids obtained on hydrolysis of ovalbumin and ovovitellin, by Osborne and his associates, were as follows (Table 9).

A comparison with the corresponding data given in Chapter III (Table 4) shows that ovovitellin resembles casein in the amino acid radicles which it contains as well as in its elementary composition.

¹ See references at the end of the chapter.

² Those who desire a fuller account of the chemistry of the egg protein should consult the original papers of Osborne and Campbell. (See references at end of chapter.)

TABLE 9. PERCENTAGES OF AMINO ACIDS FROM EGG PROTEINS

	OVALBUMIN	OVOVITELLIN
Glycin ¹	0.00	0.00
Alanin	2.22	0.75
Valin	2.50	1.87
Leucin	10.71	9.87
Prolin	3.56	4.18
Phenylalanin	5.07	2.54
Aspartic acid	2.20	2.13
Glutamic acid ²	9.10	12.95
Serin	?	?
Tyrosin	1.77	3.37
Cystin	?	?
Histidin	1.71	1.90
Arginin	4.91	7.46
Lysin	3.76	4.81
Tryptophan	present	present
Ammonia	1.34	1.25

TABLE 10. COMPARISON OF WHITE AND YOLK OF EGG³

CONSTITUENT	WHITE	YOLK
Water <i>Per cent</i>	86.2	49.5
Protein <i>Per cent</i>	12.3	15.7
Fat <i>Per cent</i>	0.2	33.3
Ash <i>Per cent</i>	0.6	1.1
Calcium (calc. as CaO) <i>Per cent</i>	0.015	0.2
Magnesium (calc. as MgO) <i>Per cent</i>	0.015	0.02
Potassium (calc. as K ₂ O) <i>Per cent</i>	0.19	0.13
Sodium (calc. as Na ₂ O) <i>Per cent</i>	0.21	0.1
Phosphorus (calc. as P ₂ O ₅) <i>Per cent</i>	0.03	1.0
Chlorine (calc. as Cl) <i>Per cent</i>	0.15	0.1
Sulphur (calc. as S) <i>Per cent</i>	0.196	0.157
Iron (calc. as Fe) <i>Per cent</i>	0.0001	0.0085
Weight per average egg <i>Grams</i>	33.	17.
Weight per average egg <i>Ounces</i>	1.2	0.6
Fuel value per average egg <i>Calories</i>	17.	60.

¹ Also called glycocoll.² Also called glutaminic acid.³ The occasional small discrepancies between the data for the entire egg and the sum of the data for white and yolk are due to the fact that the two sets of analyses did not cover exactly the same samples.

The ash constituents of the egg are, like the proteins, evidently well adapted to serve as material for the formation of body tissue. This may be inferred from the function of eggs in nature and from the success attending the use of eggs in diets designed especially for tissue building, and has also been demonstrated experimentally in laboratory feeding experiments. It will be seen from the accompanying tables that the egg is rich in all those elements which enter largely into the construction of muscle, bone, and blood; also that these are very unequally distributed between the white and the yolk.

TABLE II. NUTRIENTS IN EGGS AS PURCHASED AND EDIBLE PORTION

CONSTITUENT		ENTIRE EGG AS PURCHASED	ENTIRE EDIBLE PORTION
Shell	<i>Per cent</i>	11.2	—
Water	<i>Per cent</i>	65.5	73.7
Protein	<i>Per cent</i>	11.9	13.4
Fat	<i>Per cent</i>	9.3	10.5
Ash	<i>Per cent</i>	0.9	1.0
Calcium (calc. as CaO)	<i>Per cent</i>	0.083	0.093
Magnesium (calc. as MgO)	<i>Per cent</i>	0.013	0.015
Potassium (calc. as K ₂ O)	<i>Per cent</i>	0.148	0.165
Sodium (calc. as Na ₂ O)	<i>Per cent</i>	0.18	0.2
Phosphorus (calc. as P ₂ O ₅)	<i>Per cent</i>	0.33	0.37
Chlorine (calc. as Cl)	<i>Per cent</i>	0.09	0.10
Sulphur (calc. as S)	<i>Per cent</i>	0.17	0.19
Iron (calc. as Fe)	<i>Per cent</i>	0.0027	0.003
Weight of 100-calorie portion	<i>Grams</i>	76.	68.
Weight of 100-calorie portion	<i>Ounces</i>	2.7	2.4
Fuel value per pound	<i>Calories</i>	596.	672.
Weight per average egg	<i>Grams</i>	56.	50.
Weight per average egg	<i>Ounces</i>	2.	1.8
Fuel value per average egg	<i>Calories</i>	74.	74.

The yolk is very much richer than the white in the calcium, phosphorus, and iron compounds which (for reasons explained in Chapter I) are especially significant in human nutrition.

The phosphorus of the egg, and especially of the yolk, is present chiefly as phosphoproteins and phosphorized fats ("phosphatids," "phospholipines") in which form it is believed to be of greater food value, at least for the growing organism, than in the form of simple phosphates. (See *Chemistry of Food and Nutrition*, Chapter X.)

The iron of the egg yolk is also present in organic combination, chiefly if not entirely as a constituent of protein. Bunge separated from egg yolk a protein substance having the composition:

	<i>Per cent</i>
Carbon	42.11
Hydrogen	6.08
Nitrogen	14.73
Sulphur	0.55
Phosphorus	5.19
Iron	0.29
Oxygen	31.05

This appeared to be the substance which during incubation is changed into hæmoglobin and for this reason Bunge named it *hæmatogen*. This is believed to be typical of the iron-protein compounds which, in a well-balanced diet, furnish all the iron needed for normal nutrition, and which apparently cannot be satisfactorily replaced by the iron of medicines and mineral waters. The function of these latter forms of iron seems to be that of a drug to stimulate the blood-making organs in the body, while the iron-protein compounds of the food furnish the material from which the hæmoglobin of the blood is actually made. The richness of the egg yolk in this food-iron should therefore be recognized as adding much to the food value of the egg.

The calcium compounds of the egg have been less studied than the iron and phosphorus compounds, perhaps because the utilization of calcium in the body seems to be less dependent upon the form in which it exists in the food than in the case of iron or phosphorus. It is certain that the calcium of the egg

is well utilized and the richness of egg-yolk in calcium constitutes another important factor in the resemblance between eggs and milk as food.

The sulphur content of eggs is high — higher even than would be anticipated from the protein content, since the chief protein of the white of egg (ovalbumin) is particularly rich in sulphur. This abundance of sulphur probably has its function as a source of supply for the sulphur-rich substances of the skin, claws, and feathers of the chick. From the standpoint of human nutrition, such a high sulphur content is not altogether an advantage, since it results in a considerable preponderance of the acid-forming elements (see Chapter I) over the base-forming elements of the egg. This makes the egg an “acid-forming” food. In this respect the egg is similar to meat and unsimilar to milk. In other respects, notwithstanding the fact that milk contains about 5 per cent of carbohydrate and eggs almost none,¹ there is an essential similarity between milk and eggs in those features of their chemical nature which are most directly connected with their food value.

Nutritive Value and Place in the Diet

That the egg is a food of high nutritive value will have been inferred from the above discussion of its chemical composition, and the nature of the nutrients which it contains.

The digestibility of eggs has been studied experimentally but not in such detail as with some other articles of food. The results indicate that egg-protein is digested and absorbed to practically the same extent as milk or meat protein, about 97–98 per cent; and that the fat of egg is digested about as thoroughly as milk fat and rather more thoroughly than meat fat. It is probable that eggs “soft cooked” at a temperature below that of boiling water are the most readily and rapidly digested, but

¹ It is estimated that hens' eggs contain 0.25 to 0.5 per cent of glycogen, which, however, is not shown in the usual analyses.

the ultimate thoroughness of digestion does not seem to be greatly influenced by the method of cooking. Thorough mastication is naturally most important in the case of eggs which have been "hard boiled" or cooked at a higher temperature.

Nutritive value. There can be no doubt that the nutrients of the egg when absorbed from the digestive tract are of exceptional value in the nutrition of the body tissues. The richness of eggs in protein and fat and in compounds of phosphorus, iron, and calcium, all in forms especially adapted for conversion into body tissue, make the food value much greater than a comparison based simply on amounts of protein and energy would indicate.

Eggs are more nearly interchangeable with milk in nutritive value than is any other food, and they are richer than milk in iron. On account of this richness in iron (as well as the nature of the proteins and fats), eggs are among the first foods to be added to the milk diet of the young child, and if circumstances should arise in which no form of milk enters into the child's diet, the egg will come nearer furnishing a satisfactory substitute than will any other food. Normally, however, eggs should only supplement the milk of children's dietaries and should not be allowed to displace the milk to any appreciable extent. For the same reasons that it is adapted to the needs of the growing organism, the egg is also a very valuable food for adults who need to be "built up"; hence eggs are usually prominent in well-arranged dietaries for undernourished anemic people and especially for tuberculosis patients.

In addition to their well-known high nutritive value, eggs are popular for other reasons. They are easily cooked in a variety of ways and by their admixture it becomes possible to make many modifications in the texture, flavor, and appearance of other food materials. Doubtless it is largely because the egg facilitates so many things in cookery which would otherwise be difficult or impracticable, that the demand for eggs keeps the price

almost always higher than their food value, for general use, would seem to warrant. We have seen, however, that the real food value of eggs is much greater than a mere statement of the protein and fat content and energy value would indicate. When all the factors of food value are taken into account, a dozen eggs may fairly be considered worth as much in the dietary as two pounds at least of meat, so that, except in times of special scarcity, eggs are apt to be more economical than meat though not so economical as milk.

Trade Practices in the Egg Industry

The great value of eggs as food, the importance of keeping them in the best possible condition until consumed, and the desirability of preserving a considerable proportion of the eggs produced in time of abundance in order that undue scarcity at the time of minimum production may be avoided, make the trade practices in the egg industry a matter of large public importance.

For the individual consumer who wishes to preserve eggs when cheap, for use in time of scarcity, the best method is probably to keep the eggs immersed in a solution of water glass (sodium silicate) in a cool place. The water glass is usually purchased in the form of a concentrated (sirupy) solution of the sodium silicate which is diluted ten times its volume by addition of pure water. According to Bartlett, the diluted solution should not be strongly alkaline, and should have a specific gravity of about 1.045, in which case, fresh eggs readily sink and remain submerged. The silicate seals the pores of the eggshell and so prevents the entrance of organisms and greatly retards the passage of gases, so that oxygen is practically excluded. If the silicate is of the right composition and the eggs are kept completely submerged in a cool place, the eggs should remain without apparent change in weight, composition, or flavor for many

months, provided the eggs are clean, sound, and fresh when placed in the solution. Unless the consumer knows the origin of the eggs and is sure of their freshness at the start, the attempt to preserve cheap eggs by household methods is apt to result in disappointment.

Whether they are to be used as soon as they reach the market, or preserved on a small scale in the household or on a large scale in cold-storage warehouses, it is in any case highly important that eggs be promptly and properly collected and handled so as to reach the consumer or the storage warehouse in good condition.

At the present time are offered to the consumer, living in a large city, eggs of all degrees of freshness, from those which are guaranteed to have been laid within 24 hours of delivery to those which have been weeks in the hands of farmers and country merchants and perhaps after that several months in cold storage.

Naturally the poultryman who makes eggs his chief crop is likely to market them much more systematically than is the general farmer who produces only a few more eggs than he uses. If a local egg dealer visits the farms frequently, he may be able to get the eggs to a refrigerated warehouse while still fresh, and if subsequent shipment is in refrigerator cars and storage always at low temperatures, the eggs may travel hundreds of miles and remain weeks or months in the hands of dealers without serious deterioration. At present, however, the bulk of the eggs going into wholesale trade is not so well handled.

Pennington and Pierce estimate that there is a total loss of 7.8 per cent of the eggs marketed, as a result of improper handling, and of course this must be accompanied by a great decline in value of a large proportion of the eggs not totally lost. Irregular gathering of eggs on the farm and storage at too high a temperature result in much deterioration. There is also apt

to be delay and exposure to too high a temperature in the shipment of the eggs from the small dealer to the large packer, since eggs in "less than car lots" (technically known as "l. c. l.'s") are apt to be handled as ordinary local freight.

When the eggs reach the packer, they are cooled and candled. On the basis of their appearance on candling, they are classified as "fresh," "weak," "spots," and "rotten" (see Fig. 8) and sometimes still other categories. The marketable eggs are graded according to size, cleanliness, and to some extent freshness. The eggs are then packed in cases or crates, usually holding thirty dozen each, and shipped to a commission man at the market center from whom they pass to the wholesaler or jobber, and finally (perhaps after being kept in a cold-storage warehouse) to the retailer.

Some of the methods which are being employed for the improvement of conditions in the general egg trade are: better care of eggs on the farm and prompt delivery to egg dealers who will purchase for cash and base the price upon the quality of the eggs so that the farmer who uses good methods will profit accordingly; early cooling and consistent maintenance of low temperature somewhat as in the marketing of milk; reduction or elimination of middlemen, even to the extent of direct contracts between the farmer and consumer for regular shipments either in dozens by parcel post or in crates by express. For the latter purpose crates holding 15 dozen (half the usual commercial size) are now being made.

When direct contracts between producer and consumer are not practicable, it has been found that the losses and deterioration involved in the old methods may be largely eliminated by making use of the facilities of the dairy industry for the prompt marketing of the farmers' eggs. Such marketing of eggs "through the creamery" has been described by Slocum¹ as follows:

¹ Farmers' Bulletin 445, United States Department of Agriculture.

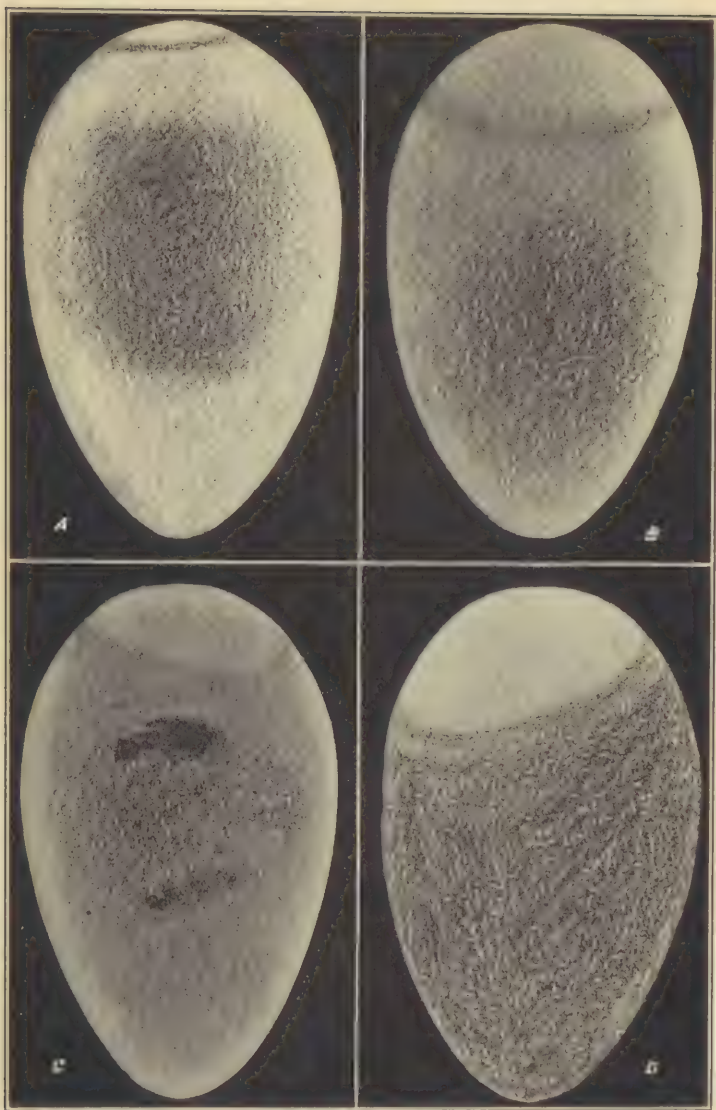


FIG. 8.—Appearance of different grades of eggs before the candle. *A*, fresh egg; *B*, shrunk (old) egg; *C*, "spot" egg (fungous growth); *D*, rotten egg.

How Eggs are Marketed through a Minnesota Creamery

The marketing of eggs in this particular instance is accomplished through a creamery in the northern part of Minnesota. Because of the fact that farmers must take their milk or cream to the creamery at frequent and regular intervals, it is an agency especially well suited to obtaining the egg in a fresh condition from the farmer. As it seems that there must be other creameries so situated that they could readily put their eggs directly in the hands of a retailer in a fair-sized city with only a short shipment, it seems well to describe in detail the methods used in this case. The volume of eggs handled in this way would, of course, probably never become so great as to make them a factor in the mass of eggs now handled commercially.

As stated before, the eggs are brought by the farmer directly to the creamery when bringing his milk. While this particular creamery is privately owned, it is essentially coöperative, in that its owner and manager is a far-sighted business man with other interests in the village, and he sees that the increased agricultural prosperity of the community will eventually be to his advantage. In consequence he is content to take a small profit for himself and to pay the farmers as liberally as possible for both their cream and eggs. Any patron of the creamery or any other person who will sign a required agreement may market his eggs in this way. At present about one hundred and thirty-five farmers are taking advantage of this method of disposing of their eggs. These egg patrons are scattered over quite a wide territory, one man finding it to his advantage to drive in 14 miles with his eggs.

The agreement reads as follows:

For the privilege of selling eggs to the creamery company and getting a market established for guaranteed fresh eggs, I, the undersigned, hereby pledge myself to comply in every way with the following rules:

I agree to deliver eggs at the creamery that will not be to exceed 8 days old and to be picked in (gathered) twice every day.

Eggs to be of uniform size (no under size or over size eggs).

Eggs to be clean and to be kept in a cool, dry cellar.

Brown eggs to be put in one carton and white in another and so marked.

Each egg to be stamped on the side and carton to be stamped on the top.

I agree not to sell any eggs that I have marked with the creamery company's trade-mark to anyone else but the creamery company, and to return stamps and other supplies that have been furnished, in case I should decide to discontinue to sell eggs to the creamery company.

It is readily discernible from the provisions of this agreement that the aim is to get a grade of uniform, clean, dependable eggs, of reasonable fresh-

ness. It might seem that requiring delivery once in eight days would not be frequent enough, but the nights in Minnesota even in summer are said to be usually cool, and this condition, together with the gathering twice a day and the storage in dry, cool cellars, must account for the fact that no complaints have been received on the score of staleness.

To every person signing the agreement quoted above a small rubber stamp is given for use in stamping the eggs and the container. This stamp plays an important part in the system of marketing. It contains the name of the creamery, the creamery brand, and a serial number for each producer. By means of the stamp which thus appears on each egg and on each package it is possible to trace the product back to the individual producer, and in consequence to place the blame for any carelessness or poor quality where it belongs. A repetition of any offense of this nature may be sufficient ground for refusing to handle the eggs of that particular producer.

When the creamery patron signs the agreement, and at such times thereafter as may be necessary, he is furnished with a supply of cartons or containers in addition to the rubber stamp. These cartons are the ordinary one-dozen size pasteboard egg boxes which are so shaped that they may be packed in a regular 30-dozen egg case.

The farmer takes these cartons home, and as the eggs are gathered each day, the clean, good-sized eggs are stamped and placed in them. When a carton is filled it is stamped on its upper side just the same as the eggs.

When the farmer comes in to the creamery with his milk or cream he brings along as many cartons or dozens of eggs as he has. The man in charge of the creamery takes these eggs, examines the packages, and gives the farmer a check for the eggs delivered that day. The cartons are then packed in substantial returnable 30-dozen egg cases and shipped to market by express. The shipping charges are paid by the consignee. The labor and cost of handling the eggs at the creamery are thus reduced to a minimum. The eggs are never candled, reliance being placed on the farmer to bring in good eggs. The cost of handling the eggs, including the cost of the carton, which is about one-half cent, is estimated to be 1 cent a dozen. The farmer in turn feels bound to be particular, knowing that any carelessness can be traced back to him and realizing that he thus jeopardizes his chances of continuing to dispose of his eggs in this manner.

The advantage of this system of marketing, to the farmers or producers, has come about in two ways: First, it has increased the price paid to them by compelling an improvement in quality, by selling more directly to the consumer, and by establishing a reputation for the eggs sold under the creamery brand. Second, it has brought about the realization that poultry raising by the general farmer is profitable, that the income from this source is consider-

able, and that it is capable of increase by keeping better fowls and giving them better care.

In this particular Minnesota village during the year 1907, which was just previous to marketing the eggs by the new method, the eggs received by the storekeepers hardly more than supplied the local demand. In fact, during the whole of that year only 15 cases, or 450 dozen eggs, were shipped out of the village. During the year 1909 nearly \$4,000 was paid out by the creamery for eggs, all of which were shipped away. The impetus which has been given the poultry business during the short time this method of marketing has been practiced may be judged from the statement of the proprietor of the creamery that from present indications he expected the egg business to double or treble during the year 1910.

The publication of this account by the United States Department of Agriculture in 1910 gave an impetus to this method of marketing eggs and it is said to be extending rapidly.

Special attention to the handling of eggs is not a new project. In Denmark a farmers' coöperative egg export association was organized in 1895 to better the market for Danish eggs by guaranteeing that eggs delivered under the association's trade-mark are strictly fresh and clean. This association handled in 1909 over 9,000,000 pounds of eggs. In Canada both the Dominion government and the Quebec government have taken up the matter and are doing what they can to forward similar coöperative work. In Australia one state has a system by which twenty-one associations of farmers each maintain a center at which a Secretary receives, tests, and grades the eggs, pays cash for them at the current market rate, and sends them to the government cold stores, receiving one cent per dozen eggs for his services. The government does the marketing and at the end of each quarter any profits are divided among those who supply the eggs (Powell). For several years the United States Department of Agriculture has been working through both the Bureau of Animal Industry and the Bureau of Chemistry for the improvement of the egg trade and now through the newly established Office of Markets, will doubtless be able to con-

tribute still more toward the solution of the problems of this industry.

Cold Storage and its Regulation

The cold storage industry as now understood is a relatively recent development. While statistics of the industry in its earlier stages are not available, it is generally accepted that only since about 1893 have the quantities of food materials placed in cold storage been large enough to have an appreciable effect upon market conditions.

It should be kept in mind that statements regarding the quantity of food "put in cold storage" do not include food kept cold while in preparation or transportation or while in the hands of the retailer, but refer, as a rule, specifically to the business conducted by cold storage warehousemen who rent space for the storage of food, which the owners wish to withhold from the market for a longer or shorter time. It is obvious that the owner's chief object in thus withholding his goods from the market is to await an increase of price; it should be equally plain that the owner cannot wish to hold the food so long as to have it lose value through deterioration. Hence the influence of cold storage in the food industry is more largely economic than hygienic, though occasionally there may be cases in which food becomes unwholesome in cold storage, either through being stored too long, or under improper conditions, or because the food was not suitable for storage in the first place.

Of the total egg production of the United States it is estimated that about one seventh (13.5 to 15 per cent) are placed in cold storage in the sense explained above, *i.e.* are sent to storage warehouses to await higher prices instead of being sent directly to the retail trade. Referring to the estimates of egg production quoted earlier in this chapter, it will be seen how great is the quantity represented by one seventh of this total. The cold storage warehouses are apt to be located in close proximity to

some large market. On the occasion of an official investigation by a committee of the State Legislature it was reported that hundreds of millions of eggs were found in the cold-storage warehouses of Hudson County, New Jersey, awaiting a rise of price in New York City.

That egg production is much larger and prices much lower in spring and early summer than in autumn and winter is a well-

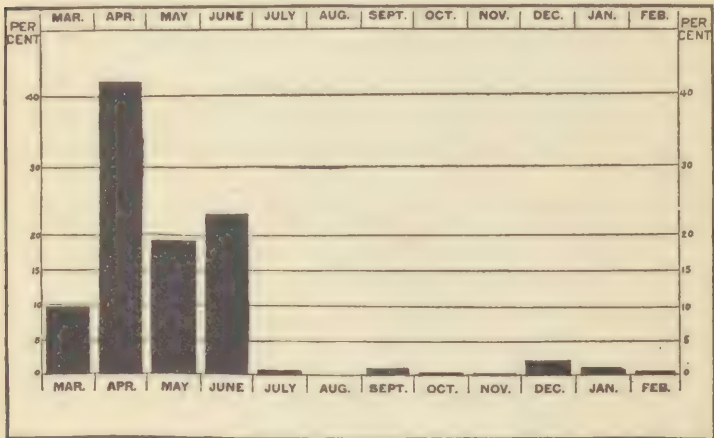


FIG. 9. — Relative quantities of eggs put in cold storage each month (by a Chicago firm). Reproduced by permission from Taylor's *Prices of Farm Products* (Bulletin 209 of the Wisconsin Agricultural Experiment Station).

recognized condition which recurs regularly year after year. The supply of eggs received by a large city is more nearly in proportion to the surplus production than to the actual production of the large areas from which the supply comes.

While the price of storage eggs is always below that of fresh eggs, it usually reaches a point sufficiently above the prices ruling in spring to yield a profit to the owner after paying the warehouse charges and insurance, and allowing for interest on the money value of the eggs. It is of course in anticipation of

this profit that eggs are placed in storage at the time of greatest abundance in the spring and early summer.

According to statistics of the United States Department of Agriculture four fifths (79.4 per cent) of all the eggs placed in cold storage are stored during April, May, and June. In the Chicago market, where large quantities of eggs are received from the Southwest as well as from the surrounding country, storage begins in March and (normally) nearly all the eggs stored are placed in storage during a period of four months. The relative quantities of eggs put into storage each month for a year by one Chicago firm are shown in Fig. 9.

Since midsummer eggs do not keep well, few eggs are placed in storage in July and August even though the price may continue low.

Of the eggs placed in storage it appears from the statistics of the United States Department of Agriculture that only 22.6 per cent are taken out within 4 months of receipt, but that 75.8 per cent are taken out within 7 months, and 99.9 per cent within 10 months. Thus it appears that more than three fourths of all the eggs which are stored remain in storage over 4 months, but practically none remain in storage longer than 10 months. The average length of storage of eggs was found to be 5.9 months. The total cost of storage was estimated at 0.57 cent per dozen per month or 3.5 cents per dozen for the average length of storage. In general the stored eggs must sell, as Professor Taylor has pointed out, at a sufficient advance on their original price to pay all the costs of storage, and in addition "enough profit to induce a business man to give his attention to this business instead of doing something else."

In the case of eggs as of other perishable foods the introduction of cold storage facilities has changed considerably the relative monthly consumption and made it more uniform throughout the year. Cold storage also tends toward greater uniformity of prices throughout the year, keeping up prices in the season

of maximum production, and diminishing somewhat the increase of price which occurs at the season of natural scarcity. The cold storage industry tends to raise the average or annual price level both because the costs of storage must in the long run be paid by the consumers and, because as the result of the steadying effect of cold storage upon prices a larger proportion of consumers now use eggs throughout the year, so that there is a much larger volume of business during the season of high prices. So far as this last factor is concerned it may fairly be considered that the standard of living is raised with the cost.

The conclusion drawn from the statistical investigation conducted by the United States Department of Agriculture (1909-1911) was that there is no just ground for complaint against the men who keep foods in cold storage except in so far as they sometimes speculate. Since the power to withhold goods from the market obviously constitutes a temptation to try to raise prices by creating an artificial scarcity (or exaggerating a scarcity which already exists), it was recommended that storage warehouses be required to make monthly reports to the government and that official estimates of the quantities of foods in storage be made public each month somewhat as the government crop reports now are. As yet there has been no action upon this recommendation, nor does the Federal government set any time limit upon cold storage. Several of the states however have laws which set such limits. Thus the laws passed by New York and New Jersey in 1911 limit the time of storage to ten months except in some particular instances.

Effect of cold storage upon eggs. Meats and poultry when stored are often kept hard frozen, but this of course is not practicable for eggs. Eggs are best stored at temperatures just above their freezing point, which of course is below that of water. From 29° to 32° F. is the usual temperature for egg storage. At such temperatures the eggs, if kept in moist air, become musty or moldy. To prevent this, the air in well-

regulated storage rooms is kept moderately dry, as the result of which moisture evaporates through the shell and the contents of the egg shrink, the size of the air chamber becoming larger. This condition is detected by candling as already explained. Other results of long storage are an increased tendency of the egg albumen to adhere to the shell membrane, and sometimes a slight crystallization of certain of the components of the egg. One of the earliest prosecutions by the government after the Food and Drugs Act became effective in 1907 was against a dealer in Washington, D. C., for selling eggs "misbranded in that they were sold as strictly fresh when not so," the evidence against the eggs being "that the albumen clung to the shell membrane, that the air chamber was greatly enlarged, and that minute rosette crystals were found in the albumen and larger rosette crystals in the yolk."

During storage the white of egg loses moisture not only by evaporation through the shell, but also by an osmotic transfer of water from the white to the yolk. Greenlee¹ has studied this point quantitatively and proposed a formula by means of which the length of time an egg had been in storage could be judged from the water content of the white if the temperature and humidity of the storage room were known.

As a result of the transfer of water from the white to the yolk of the egg, the latter expands somewhat and the membrane which separates the yolk from the white is stretched and weakened and may break and permit a spreading of the yolk into the white, especially if the egg is carelessly handled.

These results of storage may interfere seriously with the appearance and behavior of the eggs when boiled or poached, and eggs showing these properties are rated considerably below fresh eggs in market value, but it should be noted that none of these effects is indicative of decomposition or unwholesomeness or indeed of anything but purely physical changes.

¹ *Journal of the American Chemical Society*, Vol. 34, page 539.

That slight chemical changes may occur during the time that eggs are ordinarily held in storage seems probable in view of the somewhat different flavor and strength of white in fresh and storage eggs. Normally the change in flavor is no different from that which takes place in a much shorter time when the eggs are kept under household conditions. Just why the white of the storage egg shows somewhat less strength than that of the fresh egg is not entirely clear, but may be due to slight self-digestion ("autolysis") such as occurs in animal organs and tissues generally when removed from the body and protected from the action of microorganisms.

The slight changes in flavor and in behavior on cooking and the fact that storage eggs are sometimes fraudulently sold as fresh in the retail trade are sufficient to explain the prejudice against cold storage eggs which exists among many if not most consumers. But these properties should not be confused with those which are indicative of decomposition and unwholesomeness. As regards wholesomeness, there is no presumption against the cold storage egg as such. In general, storage eggs may be regarded as less desirable than those which are in reality "strictly fresh," but superior to many of the so-called "fresh" eggs which have not had the benefit of refrigeration.

Many species of organisms, both bacteria and molds, have been found in decaying eggs. In general the spoilage which takes place rapidly at high temperatures is apt to be due chiefly to bacteria, while the mustiness which develops slowly at low temperatures is often due more largely to molds. An initial infection with bacteria may occur while the egg is still within the oviduct of the hen; or organisms may gain entrance after the egg is laid, especially if it be allowed to lie in an unclean nest. The properties of the white and yolk with reference to bacterial growth are summarized by Buchanan as follows:¹ Egg white has been shown to possess distinct antiseptic properties. Many

¹ *Household Bacteriology*, page 484.

species of bacteria are quickly destroyed when mixed with it. This is not true of the yolk, for this is a favorable growth medium for many species of bacteria. It is not probable that this bactericidal property of egg white persists indefinitely, but it is doubtless responsible for the fact that the egg keeps as well as it does.

Certain types of spoilage are due to developing embryos and are therefore avoided in the case of infertile eggs.

Frozen and Dried Eggs

Freezing and drying are the two general methods of preserving eggs when removed from their shells. Pennington and also Stiles and Bates, of the United States Department of Agriculture, have made special investigations of frozen and dried eggs and the following is based chiefly on their findings. Since the centers of egg production and egg consumption are now so widely separated, it is believed that, properly conducted, the freezing and drying of eggs is an industry which is economically desirable, especially so long as the prevalent methods of handling bring to the dealers in the producing sections great numbers of eggs which are wholesome but not available for long hauls. Another important consideration is that frozen eggs can be stored at very much lower temperatures than can eggs in the shell.

As Pennington points out, the handling of eggs which have been removed from their shells is somewhat analogous to the handling of milk, and like the milk industry, should be characterized by the most scrupulous cleanliness throughout. As in the case of milk, the sources of contamination are best demonstrated by bacteriological methods and can in the main be eliminated by the adoption of such precautions as a knowledge of sanitation would suggest — cleanliness of surroundings and workers, frequent cleansing and drying of the fingers, use of appliances and containers which have been sterilized by means

of live steam, prompt freezing or drying of the egg after removal from the shell, etc. A complicating factor in this industry is that eggs do not come directly from the farm to the breaking establishment and even though the eggs be sorted by candling before going to the breakers, some of the eggs which have passed the candler prove to be distinctly bad when broken. In legitimate establishments, such an egg is rejected and the receptacle into which it was broken as well as the fingers of the breaker are rinsed before being used again. Mere rinsing, however, is not sufficient to prevent the contamination of the next egg, since large numbers of bacteria from the bad egg remain in the receptacle even though it looks and smells clean. Pennington recommends that all the fittings of the room in which eggs are broken and all the appliances and receptacles used be of metal or other non-porous material adapted to easy and thorough cleaning and steam sterilization. Each egg should be cracked on a steel blade and broken into a smooth clear glass cup. When a bad egg is encountered, the blade on which, and the cup into which, it was broken are at once replaced and sent away to be thoroughly washed and steam-sterilized. It is further recommended that all eggs received by the breaking establishment be first chilled below 40° F. for 24 hours, then candled and broken in cooled rooms and the liquid egg, while still cold (preferably below 45° F.), sent in its final container to a quick freezer.

It is hardly necessary to say that such precautions have not always been observed in the past. Stiles and Bates describe the commercial process as they found it in 1911 in Bulletin 158 of the Bureau of Chemistry, United States Department of Agriculture.

Methods of drying eggs. Eggs which have been removed from the shell may, instead of being frozen, be dried and preserved in solid form. According to Stiles and Bates, the drying expels over nine tenths of the water originally present and one pound of the dry product represents the solids of from 36 to 40 average-

sized eggs. They describe as follows four general methods found in commercial use :

Instantaneous method. In many respects the instantaneous method is highly satisfactory from the sanitary point of view because of the quickness of drying. The high temperature used probably destroys or retards the development of the less resistant organisms present in the liquid material. The liquid eggs are sprayed into a heated chamber at a temperature of about 160° F., where they are immediately reduced to a fine powder which is carried on by currents of air through cotton bags or other filtering devices, on which it is retained and finally falls down into bins. The powdered product usually contains from 3 to 5 per cent of moisture, and is ready to be packed in suitable containers for sale.

Belt method. As suggested by the name, the belt method consists in drying the liquid egg on an endless belt, made of zinc or galvanized iron strips. The belts vary in length according to the size of the rooms and amount of output. The liquid egg may be held in vats and artificially refrigerated with circulating brine, or the feeding device of the drying machine may be equipped with brine pipes to keep the product cold. The liquid egg is applied to the revolving belt through a feeding device which permits a thin film to spread evenly over its surface. This drying belt is inclosed within suitably constructed chambers into which heated filtered air is introduced. The temperature of the inclosed air surrounding the egg is about 140° F., and the time of drying can be largely governed by regulating the temperature of the air, the length of the belt, and the rate of its revolution. Each film of egg applied is usually dried in one complete revolution, and there are a large number of such films wound around the belt before separating the product from the drier. This is done by adjusting suitably-tipped metal scrapers in contact with the belt so as to remove the dried product, which then falls into drawers or bins. It requires from one and one-half to two hours to complete the first stage of the drying.

The product is next spread on wire screens and further dried by placing it in a "finisher," which is a large metal cabinet kept at 100° to 110° F. After remaining in the finisher two or three hours, the dried product is sifted and graded according to the size of the flake, or it may be ground to a uniform size or powdered. The finished product usually contains from 3 to 8 per cent of moisture. The goods are packed in suitable containers and placed in storage at low temperatures pending sale.

Disk method. The disk method consists of exposing the liquid egg in a vat to a series of large slate disks arranged on a slowly revolving shaft or axis. There are serious objections to this method as ordinarily practiced, since the

egg is not fully protected from the outside air, and more frequent handling is necessary, thus subjecting it to greater exposure to contamination. Each drying requires several dippings, which are treated at about 100° F., the hot air being blown under the disks from the side. A much longer time is required to dry eggs by this method; the machine may be run all day and the material further dried at room temperature during the night, to be scraped off the following morning and subsequently treated like other dried-egg products.

Tray or board method. The tray or board constitutes one of the simplest methods of drying and is perhaps the least satisfactory. Liquid eggs are spread by hand over boards or trays and placed on shelves in especially constructed cabinets. Hot air is forced through this cabinet, entering on one side and escaping on the other. It requires about six hours to make one drying at a temperature of 110° to 120° F.

Several films are applied in each drying, and the whole coat is allowed to dry further overnight at room temperature, to be removed on the following morning, when it is graded and packed for market.

From a sanitary viewpoint this method is highly unsatisfactory on account of the accumulation of egg material in the cracks or crevices of the boards and trays, which are not washed, but simply "cleaned" by scraping off the residual matter.

Stiles and Bates as the result of a large number of experiments to determine the bacterial content of frozen and dried products from eggs of different grades when made and stored under known conditions reached the following conclusions:

(1) Under-normal conditions, strictly fresh eggs contain few if any bacteria, and no appreciable numbers of *B. coli* in 1 cc. quantities.

(2) Frozen egg products prepared in the laboratory in Washington from second-grade eggs comprising "undersized," "cracks," "dirties," and "weak eggs" generally show a total bacterial content of less than 1,000,000 organisms per gram, while dried eggs prepared from the same grades usually contain a total bacterial content of less than 4,000,000 organisms per gram, both kinds containing but a very small number of *B. coli*; from a bacteriological standpoint they are considered an edible product.

(3) Frozen products made from "light spots," "heavy spots," "blood rings," and "rots" show bacterial counts generally ranging from about 1,000,000 to 1,000,000,000, while dried eggs made from the same grades usually contain from 4,000,000 to more than 1,000,000,000 organisms per gram with a relatively high proportion of *B. coli* and *streptococci* in both the frozen and dried material, indicating an unwholesome article, unfit for food, and only useful for tanning leathers, or for other technical purposes.

It should be noted, however, that testimony offered in the Federal courts, in a case in which condemnation of a shipment of frozen eggs was contested by the owner, tended to show that market eggs such as are accepted without question as food may contain many more bacteria, both in total numbers and of the *B. coli* type, than would be expected from the results found in the government laboratories.

The frozen eggs in question contained large numbers of bacteria, a considerable proportion of which were of the *B. coli* type. The eggs, however, showed no taint in taste or odor and no bad effects when eaten. The ammonia content, which was held to be the best chemical evidence of decomposition, was about the same as in ordinary market eggs, *vis.*, about 3 parts in 100,000.

The Federal court decided in favor of the egg company, holding that the government had not shown the eggs to be filthy, decomposed, putrid, nor unfit for human food.

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CHAPTER VI

MEATS AND MEAT PRODUCTS

THE industry of slaughtering and meat packing is the largest manufacturing industry in the United States, its value of product for the year 1909 being estimated by the United States Census of Manufactures at \$1,370,568,000.¹ This includes only the products of the 1641 slaughter houses which were of such size as to be classified as manufacturing establishments; it does not include the meats slaughtered by local butchers or on farms, which must of course be added if the estimate is to represent the value of the meat industry or the amount that consumers pay for meat. It was recently estimated by the United States Department of Agriculture that the annual meat bill of the United States approximates \$2,300,000,000 and that an advance in price of 1 cent per pound costs consumers about \$167,533,000 a year.

The meat-packing industry as we now understand it began about fifty years ago, with establishments for the curing and packing of pork at Cincinnati, which was then the center of the corn belt. The close connection between corn growing and swine raising is illustrated by a comparison of Figs. 10 and 11.

With the development of railroad transportation, and the westward extension of the corn belt, the center of the pork-packing industry moved to Chicago; and with the introduction of refrigerator cars, slaughter of beef for transportation in cold storage has grown to be a business of great magnitude.

¹ The second and third largest industries for the same year according to the same authority were: foundry and machine shop products, \$1,228,475,000; lumber and timber products, \$1,156,129,000.

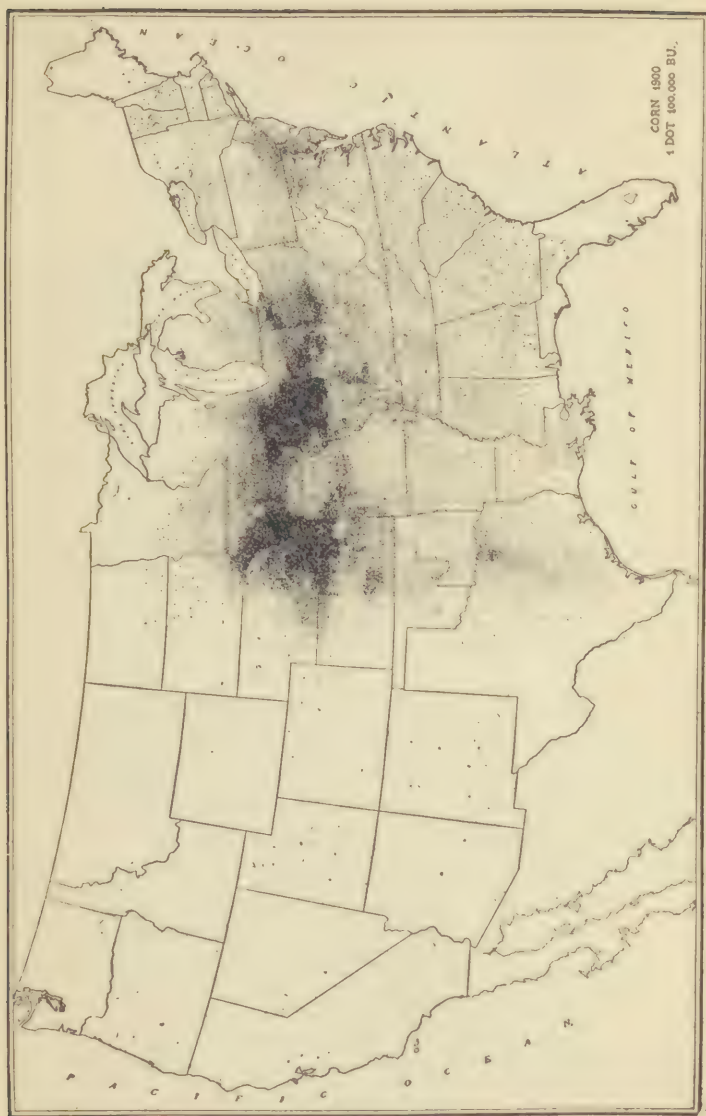


FIG. 10. — Production of corn in the United States in 1900. Reproduced by permission from Taylor's *Prices of Farm Products* (Bulletin 209 of the Wisconsin Agricultural Experiment Station).

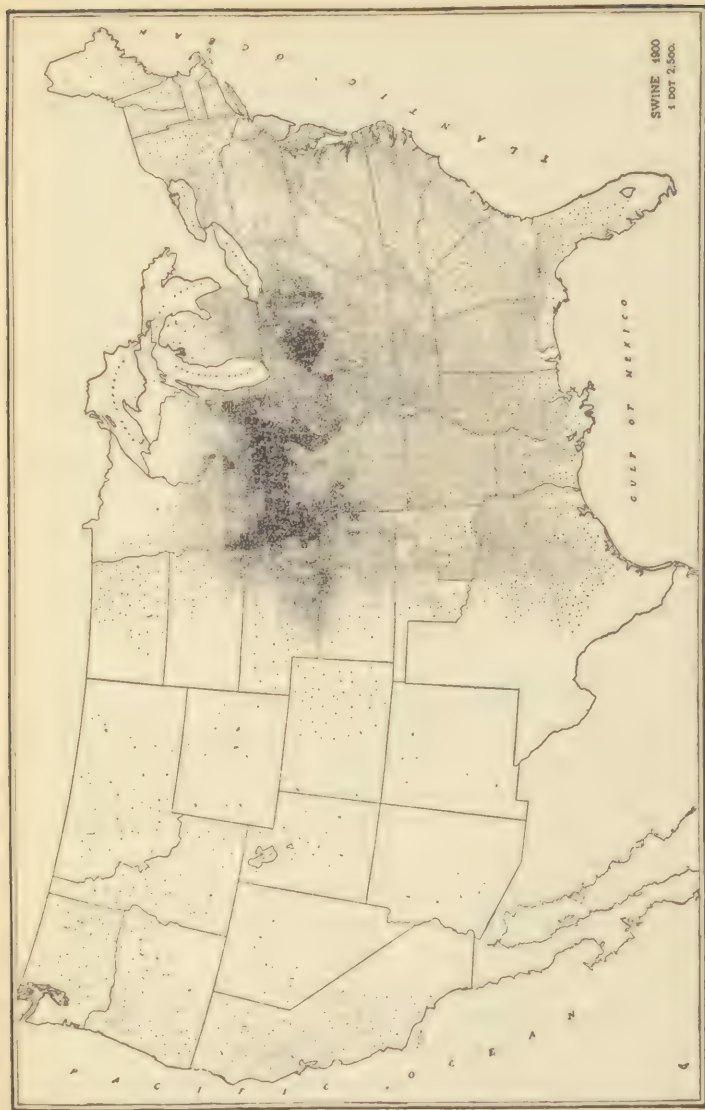


FIG. 11. — Production of swine in the United States in 1900. Reproduced by permission from Taylor's *Prices of Farm Products* (Bulletin 209 of the Wisconsin Agricultural Experiment Station).

Beef

Slaughter house methods. The animals are driven up an incline to the upper stories of the packing houses so that after slaughter the carcasses may be run from place to place by gravity. A few beeves at a time are let into the slaughter pen, where each is killed by a blow with a sledge-hammer. The floor of the pen then drops like an elevator, the beeves are rolled out upon the cement floor of the slaughter house, and the slaughter pen is raised into position again. The dead animal is at once strung up by the hind feet and, hanging head downward from a wheel on a track which runs from room to room, is bled, dressed, skinned, and the carcass divided in half without the necessity of any lifting or the use of power to transport it.

The animal is bled by cutting the carotid artery, the blood being collected by itself and for the most part dried for fertilizer, though a part of it may find its way into food products. In Europe blood sausage is a common article of food; here it is not generally popular, but a small amount of blood is sold at a large profit in dried or condensed form in patent foods. Commercial albumen may also be made from this blood.

Next the stomach and intestines are removed, the fat which adheres to them serving for the preparation of oleo oil or tallow, their contents going into the cheaper grades of tankage, their muscular walls after thorough cleaning being available for food as "tripe." The lining of the stomach, particularly of calves, may be used as a source of rennet.

Then the hide, horns, and hoofs are removed and worked for oil, gelatin, glue, leather, hair, and horn, the trimmings going into the tankage for fertilizer.

Finally the carcass is split down the backbone and the halves sent to the refrigerating room to be thoroughly chilled.

Although not more than twenty minutes may elapse between the felling of the animal and the arrival of the dressed sides at

the refrigerator, the carcass has been through the hands of a dozen or more men, each one performing some particular operation in a place arranged with special reference to the work to be done, and the convenience of handling the by-product obtained, the carcass being carried from place to place by the slight incline of the track on which its overhead trolley travels.

In beef slaughtering, the "dressed weight" usually approximates 60 per cent of the "live weight."

That part of the beef which is to be sold in a fresh state is cut into quarters which, when properly trimmed and chilled, are loaded into refrigerator cars in which the quarters are hung from the ceiling as in an ordinary cold storage room; the properly refrigerated car is shipped under seal to the market where the meat is to be retailed. Here it may remain in cold storage for some time longer before being actually sold to the consumer.

There is as yet no general consensus of opinion as to whether a limit should be set to the length of time which meat may be kept in cold storage. That some states set limits to the time of storage of all food was explained in the preceding chapter.

Naturally meat which is frozen will keep with less change than that which is merely cold, and when it is to be kept for a considerable length of time, it should be not simply chilled to the freezing point of water, but actually frozen and kept in a hard-frozen condition.

Cold storage. Richardson and Scherubel, chemists of one of the large packing houses in Chicago, have published¹ an extended chemical, histological, and bacteriological investigation of beef kept frozen for over eighteen months.

These investigators find, as had previously been found to be the case in plant tissues, that when the moist protoplasm freezes, the ice forms outside rather than inside the cell so that the

¹ *Journal of the American Chemical Society*, Vol. 30, pages 1515-1564.

microscopic examination of frozen beef shows the muscle fibers shrunk and distorted and separated by layers of ice. Richardson holds that even if bacteria could retain their activity at the temperature of frozen meat, they would be practically prevented from penetrating into the meat by these layers of ice which separate the muscle fibers, and that the histological changes which have sometimes been reported as occurring in frozen meats may be due to the mere physical effects of freezing, especially if followed by too rapid thawing, rather than to any bacterial change or other deterioration.

Richardson and Scherubel's examinations of frozen meat for bacteria both by direct microscopic and by cultural methods indicated that beef which had been kept frozen even so long as 600 days was free from bacteria at a depth of one centimeter or more from the surface. On the other hand, in meat kept at 2-4° C. bacteria had penetrated to a depth of about one centimeter in thirty days.

The principal result shown by chemical analysis of a large number of samples of beef which had been kept frozen from 33 to 554 days (in a room whose temperature varied from - 9 to - 12° C.) was that the exterior of the meat dried to a depth of from 2 to 4 millimeters in the course of a year in the open freezer, after which the progress of the drying was extremely slow. The moisture content of the portion thus dried was about 30 per cent; that of the frozen meat as a whole was about 76 per cent — the same as for corresponding cuts of fresh meat. There was no increase of ammoniacal nitrogen in the stored meats, which is considered by these investigators as strong evidence that there was no bacterial decomposition of the proteins. Neither was there any difference between the fresh and frozen meats as regards cold water extract, total nitrogen of cold water extract, or the coagulable proteins, the albumoses, or the nitrogenous extractives.

It is hardly necessary to point out that such good preservation

over long periods of time is not to be expected of meat which is merely refrigerated without being hard frozen.

Other methods of preservation. Aside from cold storage, the principal means of preserving meats are drying, canning, and the application of preservative substances.

Drying is, when applicable, a very effective method and has been long used. In some climates it is only necessary to cut the meat into strips and hang it out of doors. The "jerked beef" of the West was prepared in this way, and a mixture of dried lean meat with fat known as "pemmican" is concentrated food largely used by explorers. Dried meat is, however, by most people considered less attractive than fresh meat, and as a commercial process, the drying is slow and troublesome.

Canned meat is now put up in large quantities. Often all of the meat of the fore quarter and the cheaper cuts of the hind quarter are canned. There is a tendency to use the leaner carcasses for canning, both because the fat beefs can be sold at better prices in the fresh state and because the leaner meats are more attractive than the fat meats when canned.

Sometimes the beef is cured with salt, and usually also a little saltpeter, and then canned and sold as "canned corned beef." When preserved by canning alone without salting the product is sometimes called "canned roast beef" and sometimes simply "canned beef." The following is an outline of the latter process.

The meat selected for canning is cut into pieces usually one to four pounds each, depending upon the size of cans to be filled. It is then parboiled by putting into a tank with water and cooking with steam. Or the meat may be parboiled in larger pieces, then trimmed free from gristle and superfluous fat, and cut by machinery into approximately uniform pieces of a size proportioned to the size of the cans.

The parboiling causes a shrinkage of the meat so that (while being cooked in water) its water content is diminished.

That part of the fat which is cooked out of the meat rises to

the top and is skimmed off; the extractives, the salts, and the very small amounts of protein which are extracted remain in solution in the water in which the meat is cooked, which thus becomes of value for the making of soup stock and meat extract.

Wiley estimated that this cooking extracts a little over one part in one hundred of the protein of the meat, about one third of the "extractives," and up to one half of the salts.

After the parboiled meat has been packed in the cans, enough of the "soup liquor," made by concentrating the water in which the meat was cooked, is added to fill the spaces between the pieces and to restore so far as is practicable the flavoring constituents lost in parboiling. This added "soup liquor" may also contain salt, sugar, or molasses as a flavoring.

In canning tongue and in other cases in which the form of the product is to be preserved, the cans are filled by hand. In the case of corned beef and potted or deviled meat, the cans are filled by means of the "stuffing machine," which presses into the can approximately the required amount of meat, the weight being tested and adjusted as each can leaves the machine. The cap of the can is then soldered on by means of the "capping machine" which leaves the can completely sealed except for the small vent hole in the top. The cans are then tested for leaks and any leaks found are repaired by hand.

The cans are then sent to vacuum machines by means of which the air is exhausted from within the can and the vent holes sealed while the can is in the vacuum chamber. From the vacuum machines the cans are run out on tables and again inspected to make sure that they are free from leaks.¹

The cans are now ready for "processing," which simply means the heating of the can and contents to a sufficient temperature to insure its keeping. The temperature and time of heating depend chiefly upon the size of the cans, but also to some extent

¹ Any can found leaky at this point is repaired by hand, the vent reopened, and the can returned to the vacuum machine.

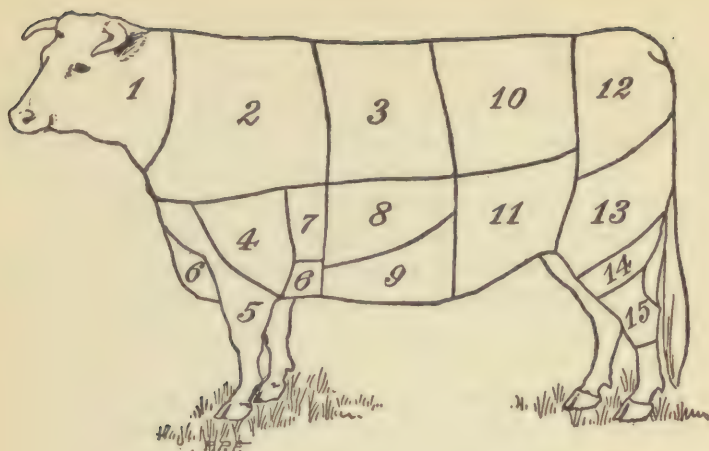
upon other conditions. Probably the most usual temperature is between 225° and 250° F. (107° – 121° C.) which is usually attained by the use of superheated steam in large iron or steel boilers or "retorts." Sometimes an oil bath is employed as a means of maintaining the high temperature. In case the nature of the product makes it desirable to avoid a temperature above boiling, the processing may be accomplished by placing the cans for a sufficient length of time in large open kettles or tanks of water which are kept at the boiling point by means of steam coils.

As the cans come hot from processing, the ends are slightly bulged outward owing to the expansion of the contents by the heating. They are now subjected to a cold spray until the contents are thoroughly chilled, when the ends of the can should be slightly concave and should remain so until the can is opened for use.

Finally the cans are washed in alkali to remove any grease, then in water, dried, painted, and labeled. Many establishments maintain warm "test rooms" at a temperature of 100 – 110° F. to which is sent a sample batch of each "run" of canned meats to make sure that no cans prove defective when kept for several days at this high temperature.

A sound can should have slightly concave ends and should give only a dull sound when struck on the top or bottom; a can which shows bulging ends and emits a hollow or drum-like sound when struck on the top or bottom is likely to be leaky, or improperly packed, or to contain material which has undergone decomposition with production of gas.

Application of preservative substances is another common and important method of preserving meats. The substances which have been used to any considerable extent for this purpose are salt, saltpeter, boric acid or borates, sulphites, vinegar, wood smoke, and sugar. Salt, sugar, vinegar, and wood smoke are condimental as well as preservative in their properties, and



1. Neck.
2. Chuck.
3. Ribs.
4. Shoulder clod.
5. Fore shank.
6. Brisket.
7. Cross ribs.
8. Plate.
9. Navel.
10. Loin.
11. Flank.
12. Rump.
13. Round.
14. Second cut round.
15. Hind shank.

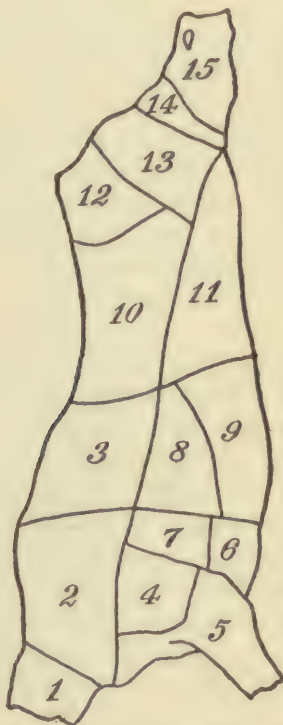


FIG 12.—Cuts of beef. (Atwater and Bryant.) U. S. Department of Agriculture

there is no restriction upon their use. Saltpeter, in addition to its preservative action, has the property of maintaining or even intensifying the red color of beef. Under the present laws it has been ruled that saltpeter may be used pending further investigation regarding its wholesomeness. Boric acid and borax, which when used are employed purely for their preservative effect, and sulphites, which act both to preserve and to give the meat a bright appearance, are not permitted under the present United States meat inspection law. In England and Canada, on the other hand, no objection is made to the use of limited amounts of boric acid or of borax.

Composition of beef. The data given in Table 12 on the composition of the various cuts and preparations of beef are based on the American analyses compiled by Atwater and Bryant. Their designation of cuts was less detailed and in some respects slightly different from that shown earlier in the chapter. The designations used by Atwater and Bryant and in the table which follows here, are as indicated in Fig. 12.

In the analyses recorded by Atwater and Bryant and summarized here, all the fat found on the respective parts of the dressed carcasses was included, whereas in practice much of this fat is trimmed off by the retail butcher, usually still more is removed during the preparation of the meat in the kitchen, and any distinct layers of fat which remain on the meat when served at the table are quite likely to be left uneaten — or at least less completely eaten than is the lean portion of the beef. For these reasons the composition of the various cuts, as shown by the averages of all analyses, or analyses of samples classified as medium fat, are apt to show a very much higher fuel value than is in practice available to the consumer of the meat. The accompanying tables show the averages of all analyses for each cut and also, wherever available, average analyses for those specimens of the cut which were described as lean or very lean.

The lean samples contain more than an average amount of protein while the average samples contain more fat than is usually eaten, so that each exaggerates the food value in one way or the other. In dietary calculations or in comparing the nutritive economy of beef and other foods it might perhaps be wise to credit the beef with the protein content shown by the average of all analyses and the fuel value shown by the analyses of the lean specimens.

TABLE 12. AVERAGE COMPOSITION OF CUTS OF BEEF¹

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
BEEF, FRESH		Per cent	Per cent	Per cent	Per cent	Per cent		Per cent	Cal.
Brisket, medium fat:									
Edible portion	3	—	54.6	15.8	16.0	28.5	—	.9	1450
As purchased	3	23.3	41.6	12.0	12.2	22.3	—	.6	1130
Chuck, including shoulder, very lean:									
Edible portion	1	—	73.8	22.3	21.3	3.9	—	1.0	564
As purchased	1	18.4	60.2	18.2	17.4	3.2	—	.8	461
Chuck, including shoulder, lean:									
Edible portion	2	—	71.3	20.2	19.5	8.2	—	1.0	702
As purchased	2	19.5	57.4	16.3	15.7	6.6	—	.8	565
Chuck, including shoulder, all analyses:									
Edible portion	13	—	65.0	19.2	18.7	15.4	—	.9	978
As purchased	12	17.3	54.0	15.8	15.5	12.5	—	.7	797
Chuck rib, very lean:									
Edible portion	1	—	75.8	22.2	21.7	1.4	—	1.1	460
As purchased	1	16.7	63.1	18.6	18.1	1.2	—	.9	387
Chuck rib, lean:									
Edible portion	11	—	71.3	19.5	19.4	8.3	—	1.0	693
As purchased	11	22.7	55.1	15.1	15.0	6.4	—	.8	535

¹Based on Atwater and Bryant's *Composition of American Food Materials*. Bulletin 28 (Revised). Office of Experiment Stations, U. S. Department of Agriculture.

TABLE 12. AVERAGE COMPOSITION OF CUTS OF BEEF—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
BEEF, FRESH		Per cent	Per cent	Per cent	Per cent	Per cent		Per cent	Cal.
Chuck rib, all analyses:									
Edible portion	21	—	66.8	19.0	18.8	13.4	—	1.0	892
As purchased	21	19.1	53.8	15.3	15.2	11.1	—	.8	730
Flank, very lean:									
Edible portion	3	—	70.7	25.9	24.8	3.3	—	1.2	605
As purchased	3	3.5	68.2	24.9	23.9	3.3	—	1.1	587
Flank, lean:									
Edible portion	3	—	67.8	20.8	19.9	11.3	—	1.0	840
As purchased	3	1.4	66.9	20.5	19.7	11.0	—	1.0	821
Flank, all analyses:									
Edible portion	16	—	59.3	19.6	18.7	21.1	—	.9	1217
As purchased	16	5.5	56.1	18.6	17.7	19.9	—	.8	1148
Loin, very lean:									
Edible portion	3	—	70.8	24.6	24.2	3.7	—	1.3	593
As purchased	3	23.0	54.6	18.8	18.5	3.0	—	.9	463
Loin, lean:									
Edible portion	12	—	67.0	19.7	19.3	12.7	—	1.0	877
As purchased	11	13.1	58.2	17.1	16.7	11.1	—	.9	764
Loin, all analyses:									
Edible portion	56	—	61.3	19.0	18.6	19.1	—	1.0	1125
As purchased	55	13.3	52.9	16.4	16.0	16.9	—	.9	988
Loin, boneless strip: ¹	6	—	66.3	17.8	16.2	16.7	—	.8	1002
Loin, sirloin butt: ¹	6	—	62.5	19.7	18.9	17.7	—	.9	1080
Loin, porterhouse steak: ¹									
Edible portion	7	—	60.0	21.9	18.6	20.4	—	1.0	1230
As purchased	7	12.7	52.4	19.1	16.2	17.9	—	.8	1075
Loin, sirloin steak: ¹									
Edible portion	21	—	61.9	18.9	18.6	18.5	—	1.0	1100
As purchased	21	12.8	54.0	16.5	16.2	16.1	—	.9	960
Loin, tenderloin	6	—	59.2	16.2	15.6	24.4	—	.8	1290
Navel, very lean:									
Edible portion	1	—	68.6	30.7	29.4	.6	—	1.4	582
As purchased	1	2.9	66.6	29.8	28.5	.6	—	1.4	565

¹ All loin parts are included under analyses of "loin."

TABLE 12. AVERAGE COMPOSITION OF CUTS OF BEEF—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N $\times$ 6.25	By difference				
BEEF, FRESH		Per cent	Per cent	Per cent	Per cent	Per cent		Per cent	Cal.
Neck, lean:									
Edible portion	2	—	70.1	21.4	20.5	8.4	—	1.0	731
As purchased	2	29.5	49.5	15.1	14.4	5.9	—	.7	515
Neck, all analyses:									
Edible portion	15	—	66.3	20.7	20.0	12.7	—	1.0	894
As purchased	15	31.2	45.3	14.2	13.6	9.2	—	.7	633
Plate, very lean:									
Edible portion	3	—	69.1	22.8	22.1	7.7	—	1.1	728
As purchased	3	37.4	43.0	13.6	13.2	5.7	—	.7	479
Plate, lean:									
Edible portion	3	—	65.9	15.6	14.6	18.8	—	.7	1051
As purchased	3	17.3	54.4	13.0	12.2	15.5	—	.6	869
Plate, all analyses:									
Edible portion	17	—	56.3	16.8	16.0	26.9	—	.8	1390
As purchased	17	19.8	44.4	13.1	12.5	22.7	—	.6	1165
Ribs, very lean:									
Edible portion	4	—	70.9	25.0	24.4	3.5	—	1.2	597
As purchased	4	23.3	54.2	19.4	18.9	2.7	—	.9	462
Ribs, lean:									
Edible portion	6	—	67.9	19.6	19.1	12.0	—	1.0	845
As purchased	6	22.6	52.6	15.2	14.8	9.3	—	.7	654
Ribs, all analyses:									
Edible portion	35	—	57.0	17.8	17.5	24.6	—	.9	1338
As purchased	34	20.1	45.3	14.4	13.9	20.0	—	.7	1078
Rib rolls, lean, as purchased	3	—	69.0	20.2	19.5	10.5	—	1.0	795
Rib rolls, all analyses, as purchased	11	—	64.8	19.4	18.8	15.5	—	.9	985
Rib trimmings, all analyses, as purchased	11	34.1	35.7	11.0	10.5	19.2	—	.5	984
Ribs, cross, very lean:									
Edible portion	1	—	65.8	18.0	18.4	14.9	—	.9	935
As purchased	1	12.8	57.4	15.6	16.1	13.0	—	.7	814
Ribs, cross, all analyses:									
Edible portion	2	—	54.9	15.9	16.1	28.2	—	.8	1440
As purchased	2	12.5	48.0	13.8	14.0	24.8	—	.7	1260

TABLE 12. AVERAGE COMPOSITION OF CUTS OF BEEF—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
BEEF, FRESH		Per cent	Per cent	Per cent	Per cent	Per cent		Per cent	Cal.
Round, very lean:									
Edible portion	6	—	73.6	22.6	22.3	2.8	—	1.3	525
As purchased	6	10.6	65.9	20.2	19.9	2.4	—	1.2	464
Round, lean:									
Edible portion	31	—	70.0	21.3	21.0	7.9	—	1.1	709
As purchased	29	8.1	64.4	19.5	19.2	7.3	—	1.0	652
Round, all analyses:									
Edible portion	62	—	67.8	20.9	20.5	10.6	—	1.1	812
As purchased	54	8.5	62.5	19.2	18.8	9.2	—	1.0	724
Round, second cut:									
Edible portion	2	—	69.8	20.4	20.5	8.6	—	1.1	721
As purchased	2	19.5	56.2	16.4	16.5	6.9	—	.9	580
Rump, very lean:									
Edible portion	4	—	71.2	23.0	22.5	5.1	—	1.2	626
As purchased	4	14.3	60.9	19.5	19.1	4.6	—	1.1	542
Rump, lean:									
Edible portion	4	—	65.7	20.9	19.6	13.7	—	1.0	938
As purchased	3	14.0	56.6	19.1	17.5	11.0	—	.9	796
Shank, fore, all analyses:									
Edible portion	15	—	70.3	21.4	20.7	8.1	—	.9	719
As purchased	15	38.3	43.2	13.2	12.7	5.2	—	.6	452
Shank, hind, all analyses:									
Edible portion	14	—	69.6	21.7	20.7	8.7	—	1.0	749
As purchased	14	55.4	31.0	9.7	9.3	3.9	—	.4	335
Shoulder and clod, very lean:									
Edible portion	4	—	76.1	21.3	21.5	1.3	—	1.1	440
As purchased	4	23.3	58.3	16.3	16.5	1.0	—	.9	337
Shoulder and clod, lean:									
Edible portion	5	—	73.1	20.4	20.4	5.4	—	1.1	591
As purchased	4	18.8	59.4	16.4	16.5	4.4	—	.9	477
Shoulder and clod, all analyses:									
Edible portion	28	—	68.9	20.0	19.7	10.3	—	1.1	784
As purchased	23	17.4	57.0	16.5	16.3	8.4	—	.9	643

TABLE 12. AVERAGE COMPOSITION OF CUTS OF BEEF — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N $\times$ 6.25	By difference				
BEEF, FRESH		Per cent	Per cent	Per cent	Per cent	Per cent		Per cent	Cal.
Fore quarter, very lean :									
Edible portion	2	—	74.1	22.1	21.3	3.6	—	1.0	548
As purchased	2	30.3	51.5	15.4	14.8	2.7	—	.7	390
Fore quarter, lean :									
Edible portion	4	—	68.6	18.9	18.4	12.2	—	.8	841
As purchased	4	22.3	53.3	14.7	14.3	9.5	—	.6	655
Fore quarter, all analyses :									
Edible portion	18	—	62.5	18.3	17.7	18.9	—	.9	1100
As purchased	18	20.6	49.5	14.4	14.1	15.1	—	.7	878
Hind quarter, very lean :									
Edible portion	2	—	72.0	24.0	23.3	3.5	—	1.2	578
As purchased	2	21.0	56.9	19.0	18.4	2.8	—	.9	459
Hind quarter, lean :									
Edible portion	4	—	66.3	20.0	19.3	13.4	—	1.0	910
As purchased	4	16.6	55.3	16.7	16.1	11.2	—	.8	760
Hind quarter, all analyses :									
Edible portion	18	—	62.2	19.3	18.6	18.3	—	.9	1100
As purchased	18	16.3	52.0	16.1	15.5	15.4	—	.8	921
Sides, very lean :									
Edible portion	2	—	73.1	23.0	22.3	3.5	—	1.1	560
As purchased	2	26.0	54.0	17.0	16.5	2.7	—	.8	419
Sides, lean :									
Edible portion	4	—	67.2	19.3	18.7	13.2	—	.9	890
As purchased	4	19.5	54.1	15.5	15.1	10.6	—	.7	714
Sides, all analyses :									
Edible portion	18	—	62.2	18.8	18.1	18.8	—	.9	1110
As purchased	18	18.6	50.5	15.2	14.7	15.5	—	.7	909
Miscellaneous cuts, free from all visible fat . . .	11	—	73.8	22.4	22.1	2.9	—	1.2	525
Clear fat	7	—	13.4	4.1	4.1	82.1	—	.4	3425
Soup stock	1	—	89.1	—	5.8	1.5	—	3.6	166
BEEF ORGANS									
Brain, edible portion . .	1	—	80.6	8.8	0.0	0.3	—	1.1	540
Heart, edible portion . .	2	—	62.6	16.0	16.0	20.4	—	1.0	1125

TABLE 12. AVERAGE COMPOSITION OF CUTS OF BEEF—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
BEEF ORGANS									
Kidney, as purchased . . .	1	19.9	63.1	13.7	—	1.9	.4	1.0	333
Beef liver, as purchased . .	1	7.3	65.6	20.2	—	3.1	2.5	1.3	539
Lungs, as purchased . . .	1	—	79.7	16.4	16.1	3.2	—	1.0	438
Marrow, as purchased . . .	1	—	3.3	2.2	2.6	92.8	—	1.3	3830
Sweetbreads, as purchased	1	—	70.9	16.8	15.4	12.1	—	1.6	800
Suet, as purchased	9	—	13.7	4.7	4.2	81.8	—	.3	3420
Tongue:									
Edible portion	3	—	70.8	18.9	19.0	9.2	—	1.0	719
As purchased	3	26.5	51.8	14.1	14.2	6.7	—	.8	530
BEEF, COOKED									
Round steak, fat partly removed	18	—	63.0	27.6	27.5	7.7	—	1.8	815
Sirloin steak, baked	1	—	63.7	23.9	24.7	10.2	—	1.4	850
Loin steak, tenderloin, broiled, edible portion	6	—	54.8	23.5	23.6	20.4	—	1.2	1260
Sandwich meat	3	—	58.3	28.0	27.9	11.0	—	2.8	958
BEEF, CANNED									
Chili-con-carne	1	—	75.4	13.3	—	4.6	4.0	2.7	502
Collops, minced	1	—	72.3	17.8	—	6.8	1.1	1.9	611
Corned beef	15	—	51.8	26.3	25.5	18.7	—	4.0	1240
Dried beef	2	—	44.8	39.2	38.6	5.4	—	11.2	932
Kidneys, stewed	2	—	71.9	18.4	—	5.1	2.1	2.5	570
Luncheon beef	1	—	52.9	27.6	26.4	15.9	—	4.8	1150
Roast beef	4	—	58.9	25.9	25.0	14.8	—	1.3	1070
Rump steak	1	—	56.3	24.3	23.5	18.7	—	1.5	1200
Sweetbreads	1	—	69.0	20.2	19.5	9.5	—	2.0	755
Tongue, ground	6	—	49.9	21.4	21.0	25.1	—	4.0	1410
Tongue, whole	5	—	51.3	19.5	21.5	23.2	—	4.0	1300
Tripe	2	—	74.6	16.8	16.4	8.5	—	.5	652
BEEF, CORNED AND PICKLED									
Corned beef, all analyses:									
Edible portion	10	—	53.6	15.6	15.3	26.2	—	4.9	1350
As purchased	10	8.4	49.2	14.3	14.0	23.8	—	4.6	1230

TABLE 12. AVERAGE COMPOSITION OF CUTS OF BEEF—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
BEEF, CORNED AND PICKLED		Per cent	Per cent	Per cent	Per cent	Per cent		Per cent	Cal.
Spiced beef, rolled	1	—	30.0	12.0	11.8	51.4	—	6.8	2320
Tongues, pickled:									
Edible portion	2	—	62.3	12.8	12.5	20.5	—	4.7	1070
As purchased	2	6.0	58.9	11.9	11.6	19.2	—	4.3	1000
Tripe	4	—	86.5	11.7	11.8	1.2	.2	.3	265
BEEF, DRIED, ETC.									
Dried, salted, and smoked:									
Edible portion	7	—	54.3	30.0	30.1	6.5	—	9.1	810
As purchased	2	4.7	53.7	26.4	25.8	6.9	—	8.9	761

Veal

Veal is the meat of calves which under the United States Meat Inspection Regulations must be not less than three weeks old at the time of slaughter.¹ Meat of calves less than three weeks old is popularly known as "bob veal."

As a food veal is generally regarded in this country with less favor than beef, and with greater suspicion the younger the animal. Thus Gilman Thompson writes: "Veal, especially when obtained from animals killed too young, is usually tough, pale, dry, and indigestible." According to Friedenwald and Rührh: "Veal is tough and indigestible, especially when obtained from animals that are killed too young. It differs considerably in flavor from beef, and contains more gelatin than the latter. As in many persons veal has a tendency to

¹ In Europe no objection is raised to the use of veal from younger calves. Edelman states that in Germany calves are commonly slaughtered at from three days to three weeks of age.

produce indigestion, it is to be avoided in all cases of digestive debility."

Laboratory experiments upon the digestibility and wholesomeness of veal are now (1913-1914) in progress in the Bureau of Animal Industry of the United States Department of Agriculture.

The method of cutting up a side of veal is quite different from that followed in the case of beef. The cuts recognized in the tables of Atwater and Bryant are shown in Fig. 13.

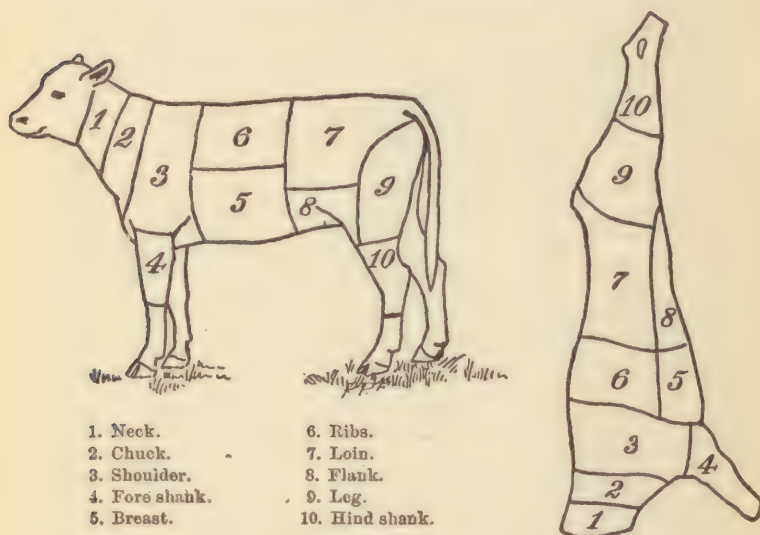


FIG. 13.—Cuts of veal. (Atwater and Bryant.) U. S. Department of Agriculture.

The average composition of the various cuts of veal, based on the results of American analyses compiled by Atwater and Bryant, is given in Table 13.

TABLE 13. AVERAGE COMPOSITION OF CUTS OF VEAL

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Breast, very lean:									
Edible portion	1	—	73.2	23.1	23.1	2.5	—	1.2	522
As purchased	1	40.8	38.0	12.3	12.3	1.3	—	.7	276
Breast, lean:									
Edible portion	3	—	70.3	21.2	20.7	8.0	—	1.0	711
As purchased	3	23.4	54.0	15.7	16.1	6.2	—	.7	538
Breast, all analyses:									
Edible portion	8	—	68.2	20.3	19.8	11.0	—	1.0	817
As purchased	8	24.5	51.3	15.3	14.8	8.6	—	.8	629
Chuck, lean:									
Edible portion	1	—	76.3	—	20.6	1.9	—	1.2	451
As purchased	1	19.0	61.8	—	16.7	1.6	—	.9	368
Chuck, all analyses:									
Edible portion	7	—	73.8	19.7	19.4	5.8	—	1.0	595
As purchased	7	19.0	59.8	16.0	15.7	4.7	—	.8	483
Flank, all analyses, as purchased	6	—	66.9	20.1	19.4	12.7	—	1.0	884
Leg, lean:									
Edible portion	9	—	73.5	21.3	21.2	4.1	—	1.2	554
As purchased	9	9.1	66.8	19.4	19.3	3.7	—	1.1	503
Leg, all analyses:									
Edible portion	10	—	71.7	20.7	20.5	6.7	—	1.1	649
As purchased	18	11.7	63.4	18.3	18.1	5.8	—	1.0	569
Leg, cutlets:									
Edible portion	3	—	70.7	20.3	20.5	7.7	—	1.1	683
As purchased	3	3.4	68.3	20.1	19.8	7.5	—	1.0	671
Loin, lean:									
Edible portion	5	—	73.3	20.4	19.9	5.6	—	1.2	599
As purchased	5	22.0	57.1	15.9	15.6	4.4	—	.9	468
Loin, all analyses:									
Edible portion	13	—	69.5	19.9	19.4	10.0	—	1.1	770
As purchased	13	18.9	56.3	16.1	15.7	8.2	—	.9	627
Neck:									
Edible portion	6	—	72.6	20.3	19.5	6.9	—	1.0	650
As purchased	6	31.5	49.9	13.9	13.3	4.6	—	.7	440

TABLE 13. AVERAGE COMPOSITION OF CUTS OF VEAL — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Rib, medium fat:									
Edible portion	9	—	72.7	20.7	20.1	6.1	—	1.1	625
As purchased	9	25.3	54.3	15.5	15.0	4.6	—	.8	469
Rib, all analyses:									
Edible portion	12	—	69.8	20.2	19.7	9.4	—	1.1	750
As purchased	12	25.0	52.3	15.2	14.8	7.1	—	.8	566
Rump:									
Edible portion	1	—	62.6	19.8	20.1	16.2	—	1.1	1020
As purchased	1	30.2	43.7	13.8	14.0	11.3	—	.8	712
Shank, fore:									
Edible portion	6	—	74.0	20.7	19.8	5.2	—	1.0	588
As purchased	6	40.4	44.1	12.2	11.8	3.1	—	.6	347
Shank, hind, medium fat:									
Edible portion	6	—	74.5	20.7	19.9	4.6	—	1.0	563
As purchased	6	62.7	27.8	7.7	7.4	1.7	—	.4	209
Shoulder, lean:									
Edible portion	2	—	73.4	20.7	20.7	4.6	—	1.3	563
As purchased	2	18.3	59.9	16.9	16.9	3.9	—	1.0	466
Fore quarter:									
Edible portion	6	—	71.7	20.0	19.4	8.0	—	.9	690
As purchased	6	24.5	54.2	15.1	14.6	6.0	—	.7	519
Hind quarter:									
Edible portion	6	—	70.9	20.7	19.8	8.3	—	1.0	715
As purchased	6	20.7	56.2	16.2	15.7	6.6	—	.8	565
Side, with kidney, fat, and tallow:									
Edible portion	6	—	71.3	20.2	19.6	8.1	—	1.0	698
As purchased	6	22.6	55.2	15.6	15.1	6.3	—	.8	540
VEAL ORGANS									
Heart, as purchased . .	1	—	73.2	16.8	16.2	9.6	—	1.0	697
Kidneys, as purchased .	2	—	75.8	16.9	16.5	6.4	—	1.3	568
Liver, as purchased . .	2	—	73.0	19.0	20.4	5.3	—	1.3	561
Lungs, as purchased . .	1	—	76.8	17.1	17.1	5.0	—	1.1	514

Mutton and Lamb

Sheep and lambs are slaughtered by bleeding and then dressed in much the same manner as cattle. The dressed weight is usually 45 to 50 per cent of the live weight.

According to Atwater and Bryant the cuts in a side of mutton or lamb number but six, three in each quarter. The "loin"

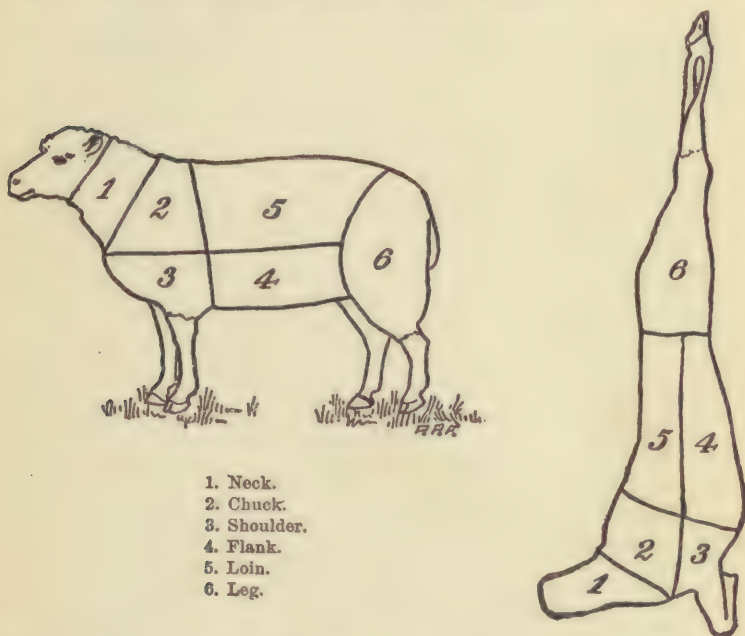


FIG. 14. — Cuts of lamb and mutton. (Atwater and Bryant.) U. S. Department of Agriculture.

extends forward to the shoulder blades and the "flank" is made to include all the under side of the animal. (See Fig. 14.)

The term "chops" is used to designate portions of either the loin, ribs, chuck, or shoulder which are cut or "chopped" by the butcher into pieces suitable for broiling or frying.

The following table (Table 14) gives the composition of cuts of mutton and lamb according to Atwater and Bryant.

TABLE 14. AVERAGE COMPOSITION OF LAMB AND MUTTON

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
LAMB, FRESH									
Breast or chuck :									
Edible portion	1	—	56.2	19.1	19.2	23.6	—	1.0	1310
As purchased	1	19.1	45.5	15.4	15.5	19.1	—	.8	1057
Leg, hind, medium fat :									
Edible portion	2	—	63.9	19.2	18.5	16.5	—	1.1	1022
As purchased	2	17.4	52.9	15.9	15.2	13.6	—	.9	844
Loin, without kidney and tallow :									
Edible portion	4	—	53.1	18.7	17.6	28.3	—	1.0	1495
As purchased	4	14.8	45.3	16.0	15.0	24.1	—	.8	1274
Neck :									
Edible portion	1	—	56.7	17.7	17.5	24.8	—	1.0	1334
As purchased	1	17.7	46.7	14.6	14.4	20.4	—	.8	1098
Shoulder :									
Edible portion	1	—	51.8	18.1	17.5	29.7	—	1.0	1541
As purchased	1	20.3	41.3	14.4	14.0	23.6	—	.8	1225
Fore quarter :									
Edible portion	1	—	55.1	18.3	18.1	25.8	—	1.0	1386
As purchased	1	18.8	44.7	14.9	14.7	21.0	—	.8	1128
Hind quarter :									
Edible portion	1	—	60.9	19.6	19.0	19.1	—	1.0	1137
As purchased	1	15.7	51.3	16.5	16.0	16.1	—	.9	957
Side, without tallow :									
Edible portion	3	—	58.2	17.6	17.6	23.1	—	1.1	1263
As purchased	3	19.3	47.0	14.1	14.2	18.7	—	.8	1020
LAMB, COOKED									
Chops, broiled :									
Edible portion	4	—	47.6	21.7	21.2	29.9	—	1.3	1615
As purchased	1	13.5	40.1	18.4	18.5	26.7	—	1.2	1425
Leg, roast	1	—	67.1	19.7	19.4	12.7	—	.8	876

TABLE 14. AVERAGE COMPOSITION OF LAMB AND MUTTON—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
LAMB, CANNED									
Tongue, spiced and cooked:									
Edible portion	1	—	67.4	13.9	14.3	17.8	—	.5	980
As purchased	1	2.6	65.7	13.5	13.9	17.3	—	.5	951
MUTTON, FRESH									
Chuck, lean:									
Edible portion	1	—	64.7	17.8	18.1	16.3	—	.9	989
As purchased	1	19.5	52.1	14.3	14.5	13.1	—	.8	794
Chuck, all analyses:									
Edible portion	10	—	48.2	14.6	14.2	36.8	—	.8	1767
As purchased	10	19.4	38.5	11.7	11.4	30.0	—	.7	1437
Flank, medium fat:									
Edible portion	8	—	46.2	15.2	14.8	38.3	—	.7	1839
As purchased	2	9.9	39.0	13.8	13.6	36.9	—	.6	1757
Leg, hind, lean:									
Edible portion	3	—	67.4	19.8	19.1	12.4	—	1.1	865
As purchased	3	16.8	56.1	16.5	15.9	10.3	—	.9	720
Leg, hind, medium fat:									
Edible portion	11	—	62.8	18.5	18.2	18.0	—	1.0	1070
As purchased	11	18.4	51.2	15.1	14.9	14.7	—	.8	874
Loin, without kidney or tail, medium fat:									
Edible portion	13	—	50.2	16.0	15.9	33.1	—	.8	1642
As purchased	12	16.0	42.0	13.5	13.0	28.3	—	.7	1400
Loin, free fat removed . .	1	—	50.5	23.7	23.0	18.5	—	1.1	1185
Neck, medium fat:									
Edible portion	10	—	58.1	16.9	16.3	24.6	—	1.0	1311
As purchased	10	27.4	42.1	12.3	11.9	17.9	—	.7	954
Shoulder, lean:									
Edible portion	1	—	67.2	19.5	18.9	12.9	—	1.0	905
As purchased	1	25.3	50.2	14.6	14.2	9.6	—	.7	675
Shoulder, medium fat:									
Edible portion	7	—	61.9	17.7	17.3	19.9	—	.9	1133
As purchased	7	22.5	47.9	13.7	13.4	15.5	—	.7	881

TABLE 14. AVERAGE COMPOSITION OF LAMB AND MUTTON — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Fore quarter:									
Edible portion	10	—	52.9	15.6	15.3	30.9	—	.9	1545
As purchased	10	21.2	41.6	12.3	12.0	24.5	—	.7	1224
Hind quarter:									
Edible portion	10	—	54.8	16.7	16.3	28.1	—	.8	1451
As purchased	10	17.2	45.4	13.8	13.5	23.2	—	.7	1198
Side, including tallow:									
Edible portion	25	—	54.2	16.3	16.0	28.9	—	.9	1475
As purchased	25	18.1	45.4	13.0	12.7	23.1	—	.7	1180
MUTTON, COOKED									
Mutton, leg roast, edible portion	2	—	50.9	25.0	25.3	22.6	—	1.2	1377
MUTTON, ORGANS									
Heart, as purchased . . .	2	—	69.5	16.0	17.0	12.6	—	.9	821
Kidneys, as purchased . .	1	—	78.7	16.5	16.8	3.2	—	1.3	430
Liver, as purchased . . .	2	—	61.2	23.1	—	9.0	5.0	1.7	878
Lungs, as purchased . . .	2	—	75.9	20.2	20.1	2.8	—	1.2	481
MUTTON, CANNED									
Corned	1	—	45.8	28.8	27.2	22.8	—	4.2	1454
Tongue	1	—	47.6	24.4	23.6	24.0	—	4.8	1423

Pork

The slaughtering and packing of pork is carried on largely in the same establishments with the beef-packing industry, but the processes are quite different. The hog is killed by bleeding and then scalded by dropping into a tank of hot water from which the carcass is drawn up through a tower in which mechanical scrapers remove the bristles, thence through the hands of suc-

cessive workmen who dress and trim the carcass, split it in half, and send the halves to the refrigerating room. This entire process is completed in about 12 minutes, the carcasses following each other over the same track with almost incredible rapidity, sometimes as many as 400 hogs per hour.

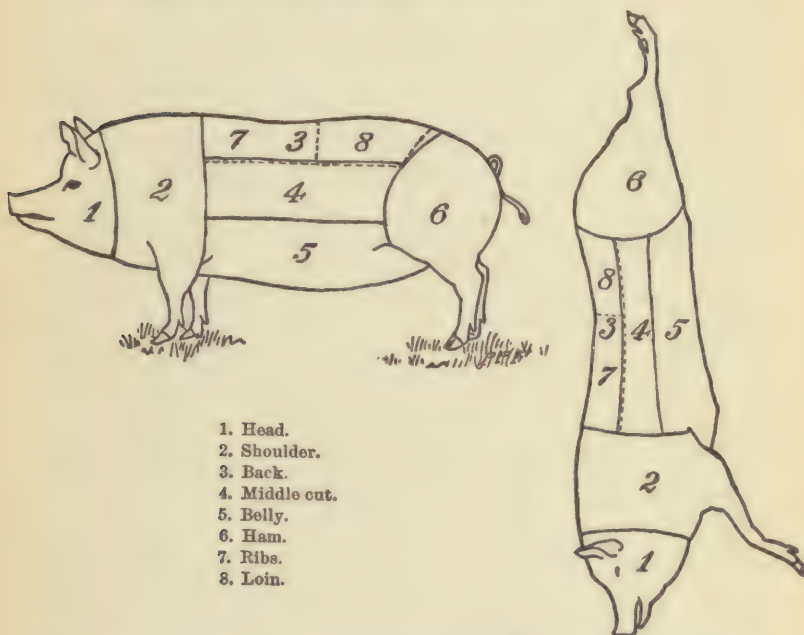


FIG. 15.—Cuts of pork. (Atwater and Bryant.) U. S. Department of Agriculture.

The by-products of slaughter are utilized according to the same general principles as in the beef industry, but with many differences in detail which need not be considered here.

Hogs are dressed without removal of the heads, and being fatter than cattle show a larger yield of dressed weight — usually 75 to 85 per cent of the live weight.

After having hung a couple of days in the chilling room the

sides of pork are taken out, cut into the usual market pieces, a part sent to the refrigerator cars to be marketed fresh and a much larger part, generally about nine tenths of the whole, is cured in various ways chiefly by salting or smoking or both.

The fat from the abdominal cavity of the hog furnishes the "leaf lard" of commerce. Lower grades of lard are rendered from trimmings and various parts not suitable for making into sausage.

Besides supplying the home market, this country exports hundreds of millions of pounds of lard each year. Lard will be discussed further in connection with other edible fats in a later chapter.

In general about one eighth of the live weight is obtained in lard and about the same in hams, while the yield of shoulders is slightly less (about one tenth of the live weight) and the remainder, aside from the head, is cut into different proportions of loin, back, ribs, middle cut, and belly according to circumstances and demands. One division of the side of pork is shown in Fig. 15, and the average composition of the cuts thus represented is given by Atwater and Bryant as follows (Table 15):

TABLE 15. AVERAGE COMPOSITION OF CUTS OF PORK

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
PORK, FRESH									
Ham, fresh, lean:									
Edible portion	2	—	60.0	25.0	24.3	14.4	—	1.3	1042
As purchased	2	.9	59.4	24.8	24.2	14.2	—	1.3	1030
Ham, fresh, medium fat:									
Edible portion	10	—	53.9	15.3	16.4	28.9	—	.8	1457
As purchased	10	10.7	48.0	13.5	14.6	25.9	—	.8	1302

TABLE 15. AVERAGE COMPOSITION OF CUTS OF PORK—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
PORK, FRESH		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Head :									
Edible portion	3	—	45.3	13.4	12.7	41.3	—	.7	1930
As purchased	3	68.4	13.8	4.1	3.8	13.8	—	.2	638
Head cheese :									
Edible portion	3	—	43.3	19.5	16.9	33.8	—	3.3	1734
As purchased	1	12.1	42.3	18.9	18.6	24.0	—	3.0	1323
Loin (chops), lean :									
Edible portion	1	—	60.3	20.3	19.7	19.0	—	1.0	1144
As purchased	1	23.5	46.1	15.5	15.1	14.5	—	.8	873
Loin (chops), medium fat :									
Edible portion	19	—	52.0	16.6	16.9	30.1	—	1.0	1530
As purchased	19	19.7	41.8	13.4	13.5	24.2	—	.8	1230
Loin, tenderloin	11	—	66.5	18.9	19.5	13.0	—	1.0	874
Middle cuts :									
Edible portion	3	—	48.2	15.7	14.8	36.3	—	.7	1768
As purchased	3	19.7	38.6	12.7	12.1	28.9	—	.7	1391
Shoulder :									
Edible portion	19	—	51.2	13.3	13.8	34.2	—	.8	1638
As purchased	19	12.4	44.9	12.0	12.2	29.8	—	.7	1435
Side, lard and other fat included :									
Edible portion	3	—	29.4	9.4	8.5	61.7	—	.4	2691
As purchased	3	11.2	26.1	8.3	7.5	54.8	—	.4	2388
Side, not including lard and kidney :									
Edible portion	11	—	34.4	9.1	9.8	55.3	—	.5	2424
As purchased	11	11.5	30.4	8.0	8.6	49.0	—	.5	2147
Clear backs :									
Edible portion	8	—	25.1	6.4	6.9	67.6	—	.4	2878
As purchased	8	5.7	23.7	6.0	6.4	63.8	—	.4	2715
Clear bellies :									
Edible portion	8	—	31.4	6.9	7.8	60.4	—	.4	2592
As purchased	8	6.2	29.5	6.5	7.3	56.0	—	.4	2429
PORK ORGANS, ETC.									
Brains, as purchased . . .	1	—	75.8	11.7	12.3	10.3	—	1.6	633

TABLE 15. AVERAGE COMPOSITION OF CUTS OF PORK—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES		FUEL VALUE PER POUND
				N $\times$ 6.25	By difference			ASH	
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
PORK ORGANS, ETC.									
Heart, as purchased . . .	1	—	75.6	17.1	17.1	6.3	—	1.0	568
Kidneys, as purchased . . .	2	—	77.8	15.5	—	4.8	0.7	1.2	490
Liver, as purchased . . .	1	—	71.4	21.3	—	4.5	1.4	1.4	596
Lungs, as purchased . . .	1	—	83.3	11.0	11.8	4.0	—	.9	379
Marrow, as purchased . . .	6	—	14.6	2.3	4.2	81.2	—	?	3357
PORK, PICKLED, SALTED, AND SMOKED									
Ham, smoked, lean:									
Edible portion	3	—	53.5	19.8	20.2	20.8	—	5.5	1207
As purchased	3	11.5	47.2	17.5	17.9	18.5	—	4.9	1073
Ham smoked, medium fat:									
Edible portion	14	—	40.3	16.3	16.1	38.8	—	4.8	1880
As purchased	14	13.6	34.8	14.2	14.0	33.4	—	4.2	1621
Ham, luncheon, cooked:									
Edible portion	2	—	49.2	22.5	24.0	21.0	—	5.8	1266
As purchased	2	2.1	48.1	22.1	23.5	20.6	—	5.7	1243
Shoulder, smoked, medium fat:									
Edible portion	3	—	45.0	15.9	15.8	32.5	—	6.7	1615
As purchased	3	18.2	36.8	13.0	12.9	26.6	—	5.5	1322
Pigs' tongues, pickled:									
Edible portion	2	—	58.6	17.7	18.0	19.8	—	3.6	1130
As purchased	2	3.2	56.8	17.1	17.5	19.1	—	3.4	1090
Pigs' feet, pickled:									
Edible portion	2	—	68.2	16.3	16.1	14.8	—	.9	900
As purchased	2	35.5	44.6	10.2	10.0	9.3	—	.6	565
Dry-salted backs:									
Edible portion	2	—	17.3	7.7	7.2	72.7	—	2.8	3110
As purchased	2	8.1	15.9	7.1	6.5	66.8	—	2.7	2858
Dry-salted bellies:									
Edible portion	2	—	17.7	8.4	6.7	72.2	—	3.4	3100
As purchased	2	8.2	16.2	7.7	6.2	66.2	—	3.2	2842

TABLE 15. AVERAGE COMPOSITION OF CUTS OF PORK—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
PORK, PICKLED, SALTED, AND SMOKED									
Salt pork, clear fat	7	—	7.9	1.9	2.0	86.2	—	3.9	3575
Bacon, smoked, all analyses:									
Edible portion	19	—	20.2	10.5	9.9	64.8	—	5.1	2836
As purchased	19	8.7	18.4	9.5	9.0	59.4	—	4.5	2597
Ham, deviled	6	—	44.1	19.0	18.5	34.1	—	3.3	1738
SAUSAGE									
Arles:									
Edible portion	1	—	17.2	26.8	24.9	50.6	—	7.3	2554
As purchased	1	5.2	16.3	25.4	23.6	48.0	—	6.9	2422
Bologna:									
Edible portion	8	—	60.0	18.7	18.4	17.6	.3	3.7	1063
As purchased	4	3.3	55.2	18.2	18.0	19.7	—	3.8	1134
Frankfort	8	—	57.2	19.6	19.7	18.6	1.1	3.4	1034
Pork, as purchased	11	—	39.8	13.0	12.7	44.2	1.1	2.2	2052
Pork and beef chopped together, as purchased .	1	—	55.4	19.4	19.5	24.1	—	1.0	1327
Summer:									
Edible portion	3	—	23.2	26.0	24.6	44.5	—	7.7	2289
As purchased	2	7.0	20.9	24.5	23.0	42.1	—	7.0	2163

Legislation and Inspection

Since meats vary so greatly in fat content it is impracticable to set standards for percentages of nutrients. Moreover, as ordinarily sold by the butcher there is little chance for any such robbing of nutrients as is involved in the skimming and watering of milk. Standards of quantitative composition have therefore not been adopted for meat itself, although there are such standards for certain manufactured products of meat as will be seen later.

Standards for meat itself relate chiefly to the healthfulness of the animals from which obtained and the sanitary conditions in which the meat is handled. These are matters of great importance. In the preface to their translation of Edelman's *Textbook of Meat Hygiene*, Mohler and Eichhorn of the United States Bureau of Animal Industry write: "Of the various classes of foods, meat is one of the most important, and it is certainly the one most subject to conditions rendering it unwholesome or even dangerous."

Not only are certain diseases of animals communicable to man through eating of the flesh, but also there is always danger through lack of cleanliness in the slaughter house, exposure to dust or flies, handling by men who are "carriers" of disease germs, or by other accident, that meat may be infected with organisms such as the *Bacillus enteritidis* which according to Buchanan multiply in the meat, producing poisonous products which are not destroyed by cooking, and which are now considered to be the commonest cause of food poisoning, including what is ordinarily called ptomaine poisoning.

The flesh may become infected with *Bacillus enteritidis* either before or after the slaughter of the animal. Veterinary inspection seeks to exclude animals thus infected as well as those diseased in other ways. To prevent the infection of the meat during slaughter house operations and subsequent handling requires strict sanitation.

Experiments cited by Buchanan¹ have shown that when *Bacillus enteritidis* is placed upon the surface of fresh meat, it rapidly penetrates to the interior of the tissues even when the meat is stored at a relatively low temperature.

Since this organism may occur in the intestinal contents and feces of even healthy animals it is plain that every precaution should be used to see not only that the animal is not diseased but also that fecal material is never allowed to come in contact

¹ *Household Bacteriology*, pages 386-389.

with the healthy tissues. This means the rigid exclusion of flies and a high degree of cleanliness in all the operations.

Veterinary and sanitary inspection and control of slaughter houses and meat packing establishments is therefore extremely important. For the establishments which send products into interstate or foreign commerce, this is provided by the United States Department of Agriculture under the meat inspection law of 1906. Official records show that a total of over 55,000,000 cattle, sheep, goats, and swine are thus inspected annually. There are, however, about as many more which are slaughtered for food in establishments doing business entirely within one state and which therefore do not come under the jurisdiction of the national authorities. Thus there is urgent need of adequate state and municipal inspection to supplement the Federal inspection in order to ensure the wholesomeness of all meat sold to consumers.

Only the provisions of the Federal inspection can be discussed here.

Federal meat inspection. In an amendment to the law making appropriation for the United States Department of Agriculture (Public Number 382, approved June 30, 1906) Congress authorized the Secretary of Agriculture to provide for inspection of all packing houses whose products enter into interstate or foreign commerce, to inspect all animals before and after slaughter and condemn all carcasses or parts thereof found unfit for food. It was provided that inspectors shall have access to all parts of the packing houses at all times of the day and night to examine all meat food products prepared "and said inspectors shall label, mark, stamp, or tag as 'Inspected and Condemned' all such products found unsound, unhealthful, and unwholesome, or which contain dyes, chemicals, preservatives, or ingredients which render such meat food products unsound, unhealthful, unwholesome, or unfit for human food: *Provided*, that subject to the rules and regulations of the Secretary of Agriculture, the

provisions hereof in regard to preservatives shall not apply to meat food products for export to any foreign country and which are prepared or packed according to the specifications or directions of the foreign purchaser, when no substance is used in the preparation or packing thereof in conflict with the laws of the foreign country to which said article is to be exported." Meats from healthy animals prepared in sanitary establishments in accordance with all requirements are labeled "Inspected and Passed," and *only meat products so labeled are allowed in interstate or foreign commerce.* The penalties provided for violation of this meat inspection law are more severe than those for violation of the general food law, and the sum appropriated for the work of meat inspection (\$3,000,000 a year) is much greater than has yet been provided for the enforcement of the Food and Drugs Act.

The Secretary of Agriculture is authorized to furnish "certificates of exemption" to farmers and retail butchers, who are exempted under the law. The regulations governing the meat inspection of the United States Department of Agriculture are published in Order No. 211 of the Bureau of Animal Industry of the Department, to which Bureau is delegated the conduct of this work. Among these regulations are detailed requirements as to sanitary arrangements in slaughter and packing houses, and the sanitary conduct of all the operations; also explicit provision as to what diseases (and in what degrees) shall cause a carcass to be condemned, what may be passed, and what intermediate grades may be rendered for lard or tallow but not used for meat. Condemned meats are treated with such colors as would prevent their sale for food, and as soon as possible are placed in rendering tanks and "a sufficient force of steam is turned into the tank and maintained a sufficient length of time effectually to render the contents unfit for any edible product." The regulation regarding preservative substances and colors provides that common salt, sugar, wood smoke,

vinegar, pure spices, and saltpeter may be added. Sodium benzoate may be used when its presence and amount are shown on the label. Only such coloring matters as may be designated by the Secretary of Agriculture as being harmless may be used and these only in such manner as the Secretary of Agriculture may designate.

The full text of the meat inspection law and some of the regulations for its enforcement, especially those which are in the nature of requirements as to sanitation, and the sanitary handling of meats and other slaughter house products intended for food will be found in the Appendix.

Federal inspection is now (1914) maintained at about 800 slaughtering and packing establishments.

The need of adequate state and city meat inspection to supplement the work of the Federal authorities has already been mentioned. This is important both to secure proper conditions in local slaughter houses and to insure proper handling of the meat in wholesale and retail markets and shops. The flesh of a healthy animal should be practically sterile at slaughter, and we have seen (page 165) that in good meat kept frozen the multiplication and penetration of bacteria is slow; but in a recent study by Weinzirl and Newton, the bacteria content of Hamburg steak as sold was found to range from 269,000 to 525,000,000 bacteria per gram, about half the samples examined showing over 10,000,000. Plainly consumers should demand a more careful handling of meat products.

Standards of Composition for Meat Products

Meat is defined by the Association of Official Agricultural Chemists¹ as "any clean, sound, dressed and properly prepared edible part of animals in good health at the time of slaughter, and if it bears a name descriptive of its kind, composition, or

¹ Standards of Purity for Food Products. Circular No. 19, Office of the Secretary United States Department of Agriculture.

origin, it corresponds thereto." It has already been explained that variations in fatness make it impracticable to set standards as to actual percentages of nutrients in meat itself. Such standards have, however, been established or proposed for a number of the manufactured products of meat.

Sausage, according to a regulation promulgated by the Secretary of Agriculture, must not contain cereal in excess of 2 per cent, nor added water or ice in excess of 3 per cent, and if water and cereal in excess of such percentage be present, the material should be labeled "sausage, water, and cereal."

This standard guards against two forms of adulteration of sausage which were more or less prevalent: (1) the direct addition of water to tough, fibrous sausage meat which under certain mechanical treatment could be made to take up a considerable quantity of added water; (2) the mixing of sausage meat with cereal products such as cracker crumbs which are cheaper in the first place than meat and which are also capable of absorbing much added water, thus adding still further to the weight. In order to simulate the appearance of ground meat such cereal products are sometimes reddened by means of special dyes ("blood color," etc.).

Beef extract was highly recommended by Liebig, who at one time supposed to it be of great nutritive value because it contained much nitrogen in a form readily absorbed from the digestive tract.

Later he realized that this was an error and said that the extract "does not give us strength but makes us aware of our strength." In other words he realized that the effect of the meat extract is that of a stimulant rather than a food.

Manufacturers of beef extract still frequently apply the term "Liebig's extract" to their product.

In South America, especially before the country was thickly settled and before facilities for transportation of meat for long distances under refrigeration had been introduced, large factories

for the manufacture of beef extract were established and droves of cattle were slaughtered for their hides and the extract obtained from their flesh, the rest of the flesh being merely a by-product.

Beef is now shipped from South America not only to Europe, but also to the United States, where it is now (1913-1914) in commercial competition with home-grown beef; but large quantities of beef extract are still made in South America and it is also of considerable importance as one of the numerous secondary products of the beef-packing industry in the United States.

Pieces of meat removed in trimming quarters and sides for market, as well as cuts for which there is less market demand, are cut small and put in water in a closed digester (generally with the addition of salt) and heated under a pressure of $1\frac{1}{2}$ atmospheres of steam for several hours until the extraction is judged to be complete, then allowed to cool, the fat removed from the surface, and the liquid strained to remove the solid pieces.

The aqueous solution thus obtained may be used either for soup stock or for making beef extract. In the latter case the liquid is concentrated in a partial vacuum to the consistency of a pasty solid or of a viscous liquid.

About 35 pounds of meat are supposed to yield 1 pound of concentrated extract which on dilution makes about 7 gallons of beef tea.

Creatin has usually been considered the characteristic nitrogen compound of meat extract. Purin bases are, however, also present and may have greater physiological significance. Potassium phosphate is the principal salt (unless extra sodium chloride has been added) and this doubtless plays a part in the stimulating effects of the extract. The acidity of the extract is usually attributed to lactic acid.

The Association of Official Agricultural Chemists has pro-

posed the following definitions and standards for meat and bone extracts, meat juices, commercial peptones, and gelatin.

Meat extract is the product obtained by extracting fresh meat with boiling water and concentrating the liquid portion by evaporation, after removal of the fat, and contains not less than 75 per cent total solids, of which not over 27 per cent is ash and not over 12 per cent is sodium chloride (calculated from the total chlorine present); not over 0.6 per cent is fat, and not less than 8 per cent is nitrogen. The nitrogenous compounds contain not less than 40 per cent of meat bases and not less than 10 per cent of creatin and creatinin.

Fluid meat extract is identical with (solid) meat extract, except that it is concentrated to a lower degree and contains not more than 75 per cent and not less than 50 per cent of total solids.

Bone extract is the product obtained by extracting fresh trimmed bones with boiling water and concentrating the liquid portion by evaporation after removal of fat, and contains not less than 75 per cent of total solids.

Fluid bone extract is identical with bone extract, except that it is concentrated to a lower degree and contains not more than 75 per cent and not less than 50 per cent of total solids.

Meat juice is the fluid portion of muscle fiber, obtained by pressure or otherwise, and may be concentrated by evaporation at a temperature below the coagulating point of the soluble proteins. The solids contain not more than 15 per cent of ash, not more than 2.5 per cent of sodium chloride (calculated from the total chlorine present), not more than 4 per cent nor less than 2 per cent of P_2O_5 , and not less than 12 per cent nitrogen. The nitrogenous bodies contain not less than 35 per cent of coagulable proteins, and not more than 40 per cent of meat bases.

Peptones are products prepared by the digestion of protein material by means of enzymes or otherwise, and contain not less than 90 per cent of proteoses and peptones.

Gelatin (edible gelatin) is a purified, dried, inodorous product of the hydrolysis, by treatment with boiling water, of certain tissues, as skin, ligaments, and bones, from sound animals, and contains not more than 2 per cent of ash and not less than 15 per cent of nitrogen.

Many of the products which have been commonly sold as meat extracts and meat juices would not meet the requirements of these definitions and standards.

Yeast extracts and perhaps other plant extracts are coming into increasing use as substitutes for or adulterants of meat extracts. Plant extract is distinguished from meat extract by the absence of creatin and creatinin. In a recent examination of "bouillon cubes" as sold in the United States, Cook finds large quantities of salt and a considerable substitution of plant extract for meat extract. The results of Cook's analyses are as follows (Table 16):

TABLE 16. THE COMPOSITION OF COMMERCIAL BOUILLON CUBES (COOK)

CUBE No. ¹	SOURCE OF MANUFACTURE	SALT	WATER AND FAT	APPROX- IMATE AMOUNT OF MEAT EXTRACT PRESENT	APPROX- IMATE AMOUNT OF PLANT EXTRACT PRESENT
		<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
1	United States	62	5.25	28	4.75
2	Germany	65	9	23	3
3	United States	65	8	18	9
4	United States	67.5	5	17.8	9.7
5	United States	59.2	7	17.8	16
6	United States	49.25	5.75	15.33	29.66
7	United States	53	4.1	14.6	28.3
8	Germany	72	5.5	14	8.5
9	United States	72.5	8.5	8.33	10.92
10	United States	72	8.5	8.17	11.33

¹ Cubes arranged in table in order of content of meat extract.

While regarded as adulterants when found in meat extracts, plant extracts may prove to be important food adjuncts on account of their "vitamines." It remains to be seen what the ultimate status of plant extract will be.

Nutritive Value of Meats and Meat Products

Although meats differ greatly in the nutrients which they contain, these differences are due in the main to simple variations in fatness. The protoplasm of the muscle cells consists mainly of proteins swollen and partially dissolved in 3 to 4 times their weight of water, in which are small amounts of other organic compounds and about 1 per cent of ash. The fat of meat is usually deposited partly in the cells, but more largely in the connective tissue between the cells, where it often forms layers of considerable thickness. Since fat neither dissolves in nor absorbs water, it is evident that the deposition of fat either in or between the muscle cells does not alter the composition of the actual protoplasm.

When an animal is killed, the muscular protoplasm coagulates (rigor mortis), but without essential change in the amount or distribution of moisture, protein, or fat. A piece of meat may therefore be regarded as mainly a mixture of fat and coagulated protoplasm, the latter being chiefly composed of protein with 3 to 4 times its weight of water. We should therefore expect the *fat-free substance* of fresh meat to contain from 20 to 25 per cent of protein regardless of the amount of fat which is or was present.

In the following table are given the average proximate composition and the percentage of protein in the fat-free substance of the entire edible portion of different meats and fish. The data are taken from the tables of analyses in Bulletin 28, Office of Experiment Stations, the figures for proteins being the mean between those given in the bulletin as "protein by difference"

and that obtained by multiplying the percentage of nitrogen by 6.25.

TABLE 17. SHOWING RELATION OF WATER, PROTEIN, AND FAT IN MEATS (AND FISH)

KIND OF MEAT OR FISH	WATER	PROTEIN	FAT	ASH	PROTEIN IN FAT-FREE
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Beef (fat)	59.7	17.75	22.0	0.9	22.8
Beef (lean)	67.2	19.0	13.2	0.9	21.9
Veal	71.3	19.9	8.1	1.0	21.7
Mutton	53.6	16.0	29.8	0.8	22.8
Lamb	58.2	17.6	23.1	1.1	22.9
Pork	34.4	9.5	55.3	0.5	21.3
Fowls	63.7	19.2	16.3	1.0	22.9
Bass	77.7	18.45	2.8	1.2	19.0
Blackfish	79.1	18.6	1.3	1.1	18.8
Halibut	75.4	18.5	5.2	1.0	19.5
Salmon	64.6	21.6	12.8	1.4	26.6
Shad	70.6	18.7	9.5	1.3	20.7
Trout (lake)	70.8	17.75	10.3	1.2	19.8

In some species the water content of the tissues changes markedly with age, but among the meats which play any important part in the diet high fat content is associated with decreased percentages of both water and protein, the ratio of water to protein, or the percentage of protein in the fat-free substance, being nearly the same for the different species, the young and mature of the same species, and the different degrees of fatness. This of course does not mean that all cuts of meat free from visible fat are of the same composition, for the manner in which the fat is deposited in the muscles differs somewhat with the species. Beef fat is mainly in distinct layers which can be mechanically separated from the lean, while in pork and some other meats, the fat exists largely as minute layers, invisible to the naked eye, surrounding the individual muscle fibers and not separable by ordinary mechanical means.

Among the fish, the differences in the protein content of the fat-free substance are larger, and the protein content appears not to be diminished in those cases in which the fat content is higher. In general the muscular protoplasm of the fatter kinds of fish is about as rich in protein as the protoplasm of meats, while among the leaner kinds of fish the muscular protoplasm is more watery.

The fuel value of meat or fish is very directly dependent upon its fatness; a gram of clear fat has a fuel value of about 9 Calories, whereas a gram of clear lean containing about one fourth gram protein has a fuel value of but 1 Calorie.

The amount of *glycogen* present in muscular tissue as usually marketed is too small to be of significance in determining the food value. Some kinds of meats tend to be richer in glycogen than others, horse-flesh than beef for example.

The *fats* vary somewhat in composition both as between different species and different organs of the same species, but so far as is known, these variations in the composition of the fat are of little nutritive significance.

Protein. As between muscle protein and gelatin, there are pronounced differences. It has long been known that gelatin alone cannot meet the entire protein requirement of the animal body. Since the development of methods for the isolation of individual amino acids from the products of hydrolysis of proteins, this deficiency in food value of gelatin has been correlated with the absence of certain amino-acid radicles, conspicuously *tryptophan*.

The amounts of amino acids thus far isolated from beef protein and from gelatin are compared in Table 18.

Opinions vary as to whether there are significant differences in the *extractives* of different kinds of meat. Hutchison and Gautier hold that there are no well-marked differences, while Wiley reports comparative analyses of light and dark meat of

fowls according to which the dark meat is much richer in "meat bases" than the light.

TABLE 18. AMINO ACIDS FROM BEEF AND GELATIN

	BEEF PROTEIN	GELATIN
	<i>Per cent</i>	<i>Per cent</i>
Glycin	2.06	16.5
Alanin	3.72	0.8
Valin	0.81	1.0
Leucin	11.65	9.2
Prolin	5.82	10.4
Oxyprolin		3.0
Phenylalanin	3.15	1.0
Aspartic acid	4.51	1.2
Glutamic acid	15.49	16.8
Serin		0.4
Tyrosin	2.20	0.0
Arginin	7.47	7.6
Histidin	1.76	0.4
Lysin	7.59	6.0
Ammonia	1.07	0.4
Tryptophan	present	absent
Summation	67.30	73.7

Among the extractives, creatin is most conspicuous, constituting about 0.25 per cent of the fresh weight of lean meat and being ordinarily the most abundant organic substance of meat extract. It is probable, however, that the properties of meat extract are due less to the creatin than to the purins and potash salts.

Purins exist in meat both "free" (as in the form of hypoxanthin, adenin, guanin) and "bound" as constituents of the nucleoproteins. Hall has determined the amounts of nitrogen existing as free and as bound purin in some different meats with the results shown in Table 19.

TABLE 19. PURINS IN DIFFERENT MEATS (HALL)

	NITROGEN IN FORM OF		
	"Free" purins	"Bound" purins	Total purins
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Beef	0.0460	0.0070	0.053
Veal	0.0430	0.0100	0.053
Ham	0.0398	0.0064	0.046
Chicken	0.0348	0.0147	0.049
Codfish	0.0299	0.0106	0.040
Liver	0.0330	0.0790	0.112
Sweetbread	0.0420	0.3510	0.393

It will be seen that the amount of purin nitrogen is about the same for the muscular flesh of the different kinds, even including fish, but is much higher in the liver and sweetbread on account of the relatively large amount of nucleoproteins in the highly nucleated secreting cells of these organs.

Ash constituents of meats. Clear lean meat consisting essentially of muscle tissue contains about 1 per cent of ash; clear fat has hardly any. The proportion of total ash or of any given ash constituent is therefore largely dependent upon the fatness of the meat and runs more or less parallel with the percentage of protein present. While the ash constituents of the muscle tissue probably differ somewhat with different species and with the same species at different ages, yet recent analyses indicate that such differences are much smaller than the usually quoted data would indicate. After study of all the data at present available, it seems best not to assume any distinct and constant differences in the ash constituents of the lean tissue of different animals, but to estimate that the ash constituents of meats in general will be proportional to the protein content. Average meat is calculated to contain *per 100 grams of protein* about as follows: CaO, 0.075 gram; MgO, 0.2 gram; K₂O, 2.0

grams; Na_2O , 0.4 gram; P_2O_5 , 2.3 grams; Cl , 0.2 gram; S , 0.9 gram; Fe , 0.015 gram.

In all meats there is a decided excess of the acid-forming over the base-forming elements. For equal degrees of fatness, the different kinds of meat appear to be practically alike in this respect.

Digestibility of meat. Meat protein is usually digested quite rapidly and shows a high percentage of absorption from the digestive tract, the average "coefficient of digestibility" being about the same for the protein of meat, milk, and eggs, viz., 97 to 98 per cent. The extractives of meat probably aid to some extent the digestion of the proteins by stimulating the flow of gastric juice. In a series of seven experiments in which extracted beef constituted a large part of the diet, the average coefficient of digestibility of the meat protein was 92 per cent. This decreased digestibility may have been due in part to the rather large amount of meat eaten (300 grams per day), but was probably at least in part attributable to the withdrawal of the extractives.

Mendel and Fine have recently reported¹ a series of digestion experiments with dogs in which the utilization of the protein of extracted meat fiber ranged from 89.3 to 91.3 per cent, while that of fresh meat was 93.7 to 94.5 per cent, leading them to the conclusion that the utilization of the nitrogen (protein) of the extractive-free meat powder "is distinctly, although slightly, lower than that of fresh meat."

The digestibility of the fat of meat is influenced by the amount eaten and its mechanical condition, whether in large or small masses. In favorable circumstances 95 per cent or more of the fat of meat is digested and utilized.

The relative digestibility of meats as the term is used popularly, and in medical writings, is apt to refer to the length of time that the meat remains in the stomach. Penzolt experimented

¹ *Journal of Biological Chemistry*, Vol. 11, pages 5-9.

by feeding different articles of food and after different intervals withdrawing the stomach contents by means of a stomach-tube. From the results of such experiments he constructed a table indicating the time which must elapse after taking a stated amount of a given food until it has entirely left the stomach. These results are widely quoted, especially in books on dietetics.

The length of time which meat remains in the stomach may vary considerably, depending upon such factors as the fat content, method of cooking, thoroughness of mastication, etc., but the ultimate utilization, at least by healthy persons, is much more nearly alike.

In a recent discussion of the extended series of experiments made under the auspices of the United States Department of Agriculture, Langworthy states: "There was nothing in the results of the experiments to indicate that any one variety of meat or any one cut of meat has any very great advantage over others in this respect."

Grindley found that differences in the rate of gastric digestion as between meats cooked in different ways, could be detected in artificial digestion experiments when the experiments were of sufficiently short duration, but practically disappeared in artificial experiments of longer duration, and in the coefficients of digestibility obtained in actual experiments with healthy men.

Food value of meat broths and extracts. The extractives of meat are stimulating, and for this reason may be useful additions to the dietary, but they have almost no food value. The creatin and purins of meat extracts may be oxidized to some extent in the body, but the energy derived from this source is negligible.

Meat broths may be so prepared as to contain some of the coagulable protein as well as the extractives, but Grindley in a long series of experiments never succeeded in obtaining more than 13 per cent of the true protein of the meat in the broth, and in the average obtained only 7 per cent, so that it is evident that at best the broths must be of but limited food value and

that the residual meat, even though tasteless, still retains by far the greatest part of the food value.

Some so-called meat extracts partake more or less of the nature of condensed broths, containing coagulated protein with the extractives, some contain proteoses or peptone, and some are enriched with dried and ground meat. Preparations of condensed meat juice and some consisting essentially of condensed blood are also commercially available. Many of these products are described by Hutchison in his *Food and Dietetics*, and by Bigelow and Cook in Bulletin 114 of the Bureau of Chemistry, United States Department of Agriculture.

Food value of gelatin. It has already been pointed out that gelatin alone cannot maintain protein equilibrium in nutrition. It is, however, not simply a "protein-sparer" as it was formerly called. Gelatin is a true protein, but not "complete" as a protein food, the "incompleteness" of food value being doubtless due to the absence of certain amino-acid radicles, conspicuously tryptophan, in the gelatin molecule. If one were to depend very largely upon gelatin as food, it would be important that some other proteins, such as those of milk, rich in the particular amino acids which gelatin lacks, should also be represented in the diet.

Relative Economy of Different Cuts of Meat

It is hardly possible to generalize in regard to the relative economy of the meats of different species, because of the wide variations of price in different localities, and because of the different significance of lean and fat meats as food.

It is, however, instructive to consider the relative economy of different cuts from the same animal, especially in the case of beef. This has recently been studied in some detail by Hall and Emmett,¹ an abstract of whose data and discussion follows:

¹ Illinois Agricultural Experiment Station, Bulletin 158.

In the experiments at the Illinois station, three each of choice and prime steers from the university herd were slaughtered and determinations made of: (1) the relative proportions of lean, visible fat, and bone in each of the retail and wholesale cuts of beef; (2) the chemical composition and nutritive value of the boneless meat of the various wholesale cuts; and (3) the net cost to the consumer of the lean, the gross meat, and the food nutrients in each cut at current market prices.

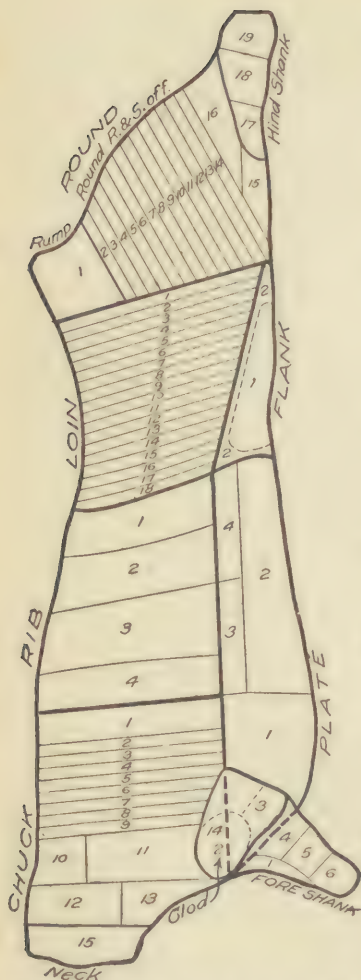
The relative cost of the lean and of the total meat in the straight wholesale cuts at market prices is shown in Table 20.

TABLE 20. COST OF LEAN AND OF TOTAL MEAT IN THE STRAIGHT WHOLESALE CUTS AT MARKET PRICES

STRAIGHT WHOLESALE CUTS	WHOLESALE PRICE PER POUND OF CUT	COST PER POUND OF LEAN IN CUT	COST PER POUND OF TOTAL MEAT IN CUT
	<i>Cents</i>	<i>Cents</i>	<i>Cents</i>
Loin	18.5	31.6	20.5
Rib	15.0	27.1	17.5
Round	11.5	17.8	13.9
Chuck	9.5	13.7	10.8
Plate	8.0	15.8	8.7
Flank	8.0	22.0	8.0
Fore shank	5.0	10.5	8.4

The net cost per pound of lean is, in general, greatest in the cuts which command the highest prices, and *vice versa*. The flank is an exception to this rule, and the chuck is more economical in this respect than the plate. Referring to the last column, it is also observed that the more expensive the cut, the greater the cost per pound of visible fat and lean combined, the flank being the only exception. From these figures it is apparent that food values of beef cuts do not correspond to their wholesale market prices, and that the cheaper cuts are by far the most economical sources of both lean and fat meat. On the whole, the different cuts vary more widely in net cost of food ingredients than in market price per pound of gross meat. The following discussion tends to confirm these statements.

The manner of cutting and the location of the different retail cuts are shown in Fig. 16.



HIND QUARTER

ROUND

Rump

- 1 Rump
- Round; rump & shank off.
- 2 Round steak, first cut.
- 3-13 Round steaks.
- 14 Round steak, last cut.
- 15 Knuckle soup bone.
- 16 Pot roast.
- Hind shank.
- 17, 18 Soup bones.
- 19 Hock soup bone.

LOIN

- 1 Butt-end sirloin steak.
- 2 Wedge-bone sirloin steak.
- 3, 4 Round-bone sirloin steak.
- 5, 6 Double-bone sirloin steak.
- 7 Hip-bone sirloin steak.
- 8 Hip-bone porterhouse steak.
- 9-15 Regular porterhouse steak.
- 16-18 Club steaks.

FLANK

- 1 Flank steak.
- 2 Stew.

FORE QUARTER

RIB

- 1 11th & 12th Rib roast.
- 2 9th & 10th Rib roast.
- 3 7th & 8th Rib roast.
- 4 6th Rib roast.

CHUCK

- 1 5th Rib roast.
- 2-9 Chuck steaks.
- 10-13 Pot roasts.
- 14 Clod.
- 15 Neck.

PLATE

- 1 Brisket.
- 2 Navel.
- 3, 4 Rib ends.

FORE SHANK

- 1 Stew.
- 2 Knuckle soup bone.
- 3-6 Soup bones.

FIG. 16. — Retail cuts of beef. (Hall and Emmett.) Courtesy of Illinois Experiment Station and United States Department of Agriculture.

Retail Cuts

Loin cuts. Loin steaks averaged 59 per cent lean, 32 per cent visible fat, and 9 per cent bone. Sirloin steaks in general contained a greater proportion of lean and smaller proportion of fat than porterhouse and club steaks.

Rib cuts. Rib roasts contained, on the average, 55 per cent lean, 30 per cent visible fat, and 15 per cent bone. The greatest percentage of lean was found in the sixth rib roast, and the smallest in the eleventh and twelfth rib cut.

Round cuts. The various cuts made from the round averaged 65 per cent lean, 18 per cent visible fat, and 17 per cent bone. Round steaks contained 74 to 84 per cent lean, the rump roast 49 per cent, round pot roast 85 per cent, and soup bones 8 to 66 per cent. The maximum percentage of fat was found in the rump roast, and the maximum percentage of bone in the hock soup bone.

Plate cuts. The brisket, navel, and rib ends averaged 51 per cent lean, 41 per cent fat, and 8 per cent bone. The brisket and navel were similar in proportions of the different constituents, but the rib ends were slightly higher in percentage of bone and lower in lean.

Flank cuts. The flank steak contained 83 per cent lean and 16 per cent fat; and the flank stew, 64 per cent lean and 35 per cent fat.

Fore shank cuts. Soup bones from the fore shank varied from 17 to 69 per cent lean and from 25 to 75 per cent bone. The boneless shank stew contained 83 per cent lean and 17 per cent visible fat.

Retail trimmings. Trimming the loin steaks reduced their weight 12 per cent, and the trimmings were about four fifths fat and one fifth bone. Round and chuck steaks were reduced but 5 per cent in weight by trimming, only fat being taken from the former as a rule and principally bone from the latter. Other cuts that were materially affected by cutting off surplus fat and bone were the rump, shoulder pot roast, and neck.

Relative Economy of the Various Retail Cuts

From the proportions of lean, fat, and bone in the different cuts, their relative economy at retail market prices may be determined. The net cost of lean meat is an approximate index of the relative economy of steaks and roasts, since they are purchased and used primarily for the lean they contain; but in comparing boiling, stewing, and similar meats the cost of gross meat, or fat and lean combined, should be more largely considered, because the fat is more completely utilized, as in the case of meat loaf, hash, Hamburger, and corned beef. Soup bones, being valued for flavoring matter as well as for the

nutritive substance they contain, are more difficult to compare with other cuts in respect to relative economy. They vary materially, however, in proportions of edible meat and waste, and should therefore be studied in this connection.

The following table (Table 21) shows the cost of lean and of total meat in the various retail cuts at market prices.

Taking the net cost of the lean meat as a basis of comparison, we learn from these data that the most expensive steaks at the prices given are the porterhouse cuts, followed by the club, sirloin, flank, round, and chuck steaks. Of the different roasts, the first-cut prime ribs are the most costly in terms of lean meat, and the rump roast is the most economical. The various boiling and stewing pieces furnish lean meat more economically at market prices than either the roasts or steaks, the rib ends and brisket being the dearer cuts of this class, while the neck and shank stews are relatively cheapest. Several of the soup bones are very economical sources of lean meat, particularly the middle cuts of both shanks, and only one of them is extremely expensive even on this basis. In general the wide variation between the various cuts in net cost of lean is remarkable, ranging from 7.5 cents in one of the soup bones to 40.5 cents in a prime rib roast, and up to 62.5 cents in the hock soup bone, the latter, however, being used primarily for its flavoring substance rather than for lean meat. It will be observed, also, that the market prices of the cheaper cuts correspond much more closely to their net cost of lean meat than is true of the higher-priced steaks and roasts.

The net cost per pound of gross meat, or lean and fat combined, varies much less as between the different cuts than does the net cost per pound of lean, because the proportions of total meat are more nearly uniform than the percentages of lean. The various steaks and roasts rank in substantially the same order as to relative economy on this basis as on the basis of lean meat. The rib roasts, however, are considerably more economical as compared with the porterhouse and sirloin steaks when all the edible meat is considered. The rump shows a very low cost per pound of edible meat, due to the large proportion of fat it contains; and a still further difference is noticed in the case of the rib ends, brisket, navel, flank, neck, and several of the soup-bone cuts. The stewing meats are generally the most economical sources of edible meat at these prices, while porterhouse steaks are the most expensive.

On the whole, the data clearly show that the cheaper cuts of beef are by far the most economical sources both of lean and of total edible meat, including fat and lean. . . . No correlation exists between market prices and the proportion of flavoring substances contained in various portions of the carcass, and cooking tests indicate that the proportion of waste and shrinkage is not necessarily greater in the cheaper than in the more expensive cuts. It is

TABLE 21. COST OF LEAN AND OF TOTAL MEAT IN THE VARIOUS
RETAIL CUTS AT MARKET PRICES

RETAIL CUTS	DIAGRAM NUMBER (FIG. 16)	RETAIL PRICE PER POUND OF CUT	COST PER POUND OF LEAN MEAT IN CUT	COST PER POUND OF LEAN AND FAT MEAT IN CUT
		<i>Cents</i>	<i>Cents</i>	<i>Cents</i>
Steaks:				
Porterhouse, hip bone . . .	8	25	38.6	28.9
Porterhouse, regular . . .	10	25	40.2	27.2
Club steak	18	20	32.1	22.6
Sirloin, butt end	1	20	25.3	20.6
Sirloin, round bone . . .	3	20	28.3	21.1
Sirloin, double bone . . .	5	20	28.7	22.7
Sirloin, hip bone	7	20	32.3	24.2
Flank steak	1	16	19.3	16.0
Round, first cut	2	15	17.0	15.3
Round, middle cut	6	15	17.3	15.6
Round, last cut	14	15	19.3	16.0
Chuck, first cut	2	12	18.3	14.1
Chuck, last cut	9	12	15.7	13.1
Roasts:				
Prime ribs, first cut . . .	1	20	40.5	22.9
Prime ribs, last cut . . .	4	16	26.1	18.8
Chuck, fifth rib	1	15	22.8	17.3
Rump	1	12	19.4	12.8
Boiling and stewing pieces:				
Round pot roast	16	10	11.6	10.1
Shoulder clod	14	10	12.3	10.5
Shoulder pot roast	11	10	14.3	11.6
Rib ends	3	8	16.2	9.2
Brisket	1	8	15.0	8.7
Navel	2	7	12.8	7.7
Flank stew	2	7	10.9	7.1
Fore shank stew	1	7	8.5	7.0
Neck	15	6	8.5	7.0
Soup bones				
Round, knuckle	2	5	26.3	12.5
Hind shank, middle cut . .	18	5	7.5	6.3
Hind shank, hock	19	5	62.5	26.6
Fore shank, knuckle	2	5	17.2	12.5
Fore shank, middle cut . .	4	5	12.5	9.4
Fore shank, end	6	5	28.8	20.9

evident, therefore, that retail prices of beef cuts are determined chiefly by considerations other than their food value, such as tenderness, grain, color, general appearance, and convenience of cooking. . . . To such an extreme has this condition developed that a portion of the carcass (loins and ribs), forming only about one fourth of its weight, represents nearly one half of its retail cost. In view of the large place which meat occupies in the American diet, amounting to nearly one third of the average expenditure for all food, the importance of an intelligent understanding of the subject on the part of the consumer is readily apparent.

Not only are the foregoing statements true of meat producers and consumers as individuals, but it is highly essential to the entire beef-cattle industry, on the one hand, and the economic welfare of the beef-eating public, on the other, that a more intelligent understanding of the different cuts of meat be acquired by consumers generally. An increased demand for those portions of the carcass which are now difficult for the butcher to dispose of would contribute largely toward a more stable condition of the trade and thus enable the producer to operate with greater confidence and economy. At the same time it would effect a tremendous saving to the consumer. . . . There seems to be no relation between market prices and the percentages of fat, protein, extractives, and ash. The cheaper cuts appear to be as valuable and in some cases actually more so than the higher priced cuts from the standpoint of protein and of energy. These statements do not take into account the factors of tenderness nor the influence the degree of fatness may have upon the palatability of cooked meat. In purchasing meat for protein primarily, the neck, shanks, and clod are the most economical cuts; the plate, chuck, flank, and round follow; with the rump, rib, and loin as the most expensive. From the standpoint of fuel value, the flank, plate, neck, and shank cuts are the cheapest, while the rib, loin, and round are the most expensive. Considering both factors, protein and fuel value, and along with these the adaptability of the meat for general use the clod, chuck, and plate are the most economical cuts at the retail prices given.

Place of Meat in the Diet

Authorities seem to agree in the estimate that in the United States about one third of the total expenditure for food materials is for meat.

Roberts of the United States Department of Agriculture, using data from the census of 1900, estimated the yearly per capita consumption of meat in this country as follows:

	POUNDS
Beef	78.71
Veal	3.35
Pork (including hams and bacon)	88.12
Mutton and lamb	8.57
Total meat per capita	178.75

The total meat consumption per capita for several of the European countries as estimated for the same year by Rew of the Royal Statistical Society, England, as quoted by Roberts was :

	POUNDS
Great Britain and Ireland	122
Germany	99
France	80
Sweden and Norway	62
Denmark	76
Belgium	70

That the per capita consumption of meat in the United States is almost half as high again as in the United Kingdom and fully twice as high as on the continent of Europe is perhaps not generally known, and is certainly a very significant fact worthy of more attention than it has yet received.

What are the reasons for the exceptionally high rate of meat consumption in America, and is this departure from the practice of the older countries an improvement?

The flavor of meat is well liked by most people, its extractives certainly stimulate the flow of the digestive juices and probably have some stimulating action upon the body generally. Meat is a food quickly cooked and (in general) readily digested, and tradition (both popular and scientific) associates meat-eating with muscular stamina, vigor, and initiative, with success in the chase in earlier days and in more recent generations with success and prosperity generally. With this attitude toward meat as a food, Europeans coming to America and finding here a more abundant supply of meat than that to which they had been accustomed, have naturally made meat a larger part of their diet than it was

or is in the countries from which they came. So long as game was abundant, pasturage unlimited, and a relatively small proportion of the land was under systematic cultivation, meat was cheap as compared with other foods. Now that game has become a negligible factor in the food supply, and there is no longer free pasturage, the production of meat involves feeding the animals with farm crops, especially grain. Since only a fraction of the nutrients of the grain is converted into, and retained as, body material by the animal, and scarcely half the total body weight of the animal is utilized as food for man, it is evident that the meat will be a much more costly food than, for instance, the grain which if not fed to the animal might have been utilized directly as human food. In the nature of the case, meat must always be an expensive food wherever frontier conditions have ceased to exist. Thus the purely economic ground for a high per capita consumption of meat in the United States is no longer tenable. Is it probable that the eating of such a large amount of meat is physiologically advantageous?

For people whose occupations are largely sedentary or at any rate do not involve much vigorous muscular exercise, a too liberal use of meat may bring on uric acid disorders or may result in excessive intestinal putrefaction. The purin substances which give rise to uric acid in the body are much more abundant in meats than in other staple foods, and it seems also well established that meat proteins are more susceptible to putrefaction in the intestine, giving rise to absorption of putrefactive products which are more or less injurious ("autointoxication"), than are the proteins of most other foods. Thus the two chief objections to a high-protein diet are more applicable to meat than to other high-protein foods. Another fact to be borne in mind is that the meats contain a large excess of acid-forming over base-forming elements. In a mixed diet containing a limited amount of meat this is easily offset by foods in which the base-forming elements predominate, but when the amount of meat eaten is

too large, there may result an excessive preponderance of acid-forming elements in the diet as a whole. This subject, as well as that of intestinal putrefaction, will be referred to again in the discussion of the place of vegetables in the diet (Chapter IX).

It is difficult to balance the advantages and disadvantages of meat as a food and to reach a confident conclusion as to just how prominent a place it should have in the diet, both because so many factors enter into the problem and because so many of those who have studied the subject and published their conclusions appear to have been more or less influenced by controversial bias engendered by the vegetarian propaganda. The following quotation from Tigerstedt represents an opinion which seems neither radical nor reactionary.

“From a purely physiological point of view, we can find no reason why a healthy man should forego the use of so excellent an article of food, considered with respect to its content of protein and fat, or its eminent adaptability, as we know meat to be. But in so stating, I do not wish to be understood as saying that one should eat any quantity of meat he pleases, or should cover too much of his requirements with meat. In too large quantities the extractive substances found in meat may possibly produce disorders of one kind or another in the body. The metabolism might also take an abnormal or unfavorable form, if the fluids of the body were flooded with too much protein.” This moderate and conservative warning against too free a use of meat as food was written, it is important to remember, in a Scandinavian textbook and was therefore addressed to those whose average rate of meat consumption was less than half as much as ours.

On the whole, it seems reasonable to conclude both from such general considerations as have just been suggested and from the results of statistical and experimental studies too detailed for discussion here, that a reduction of our meat consumption to something like half the present amount (*i.e.* to about what has

been reached through the longer experience of the European nations) is desirable on both economic and physiological grounds.

When one sixth instead of one third of the total expenditure for food is for meats, the dietary is usually both more economical and better balanced.

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CHAPTER VII

POULTRY, GAME, FISH, AND SHELLFISH

POULTRY, game, fish and shellfish belong in their essential characteristics with the meat foods discussed in the last chapter. They are treated separately here, not so much in deference to the traditional distinction between flesh, fish, and fowl as because the products now to be considered are usually not classed as belonging to the slaughter house industry and do not come under the provisions of the meat inspection law.

Poultry

The value of poultry produced in the United States is estimated by the Census Bureau at somewhat over \$200,000,000 annually (for the year 1909, \$202,506,272). We have already seen (Chapter V) that the poultry and egg industry is widely distributed in the United States. The total number of farms which reported fowls on hand April 15, 1910, was 5,585,032 and the number of fowls reported was 295,880,000.

Much of the poultry now offered for sale is produced hundreds of miles from its market. The transportation of live poultry presents numerous problems most of which lie outside the scope of this book. The shipping and handling of poultry killed at a distance from market involves obvious possibilities of deterioration. That such deterioration may be avoided, the methods of dressing poultry and of maintaining efficient refrigeration in transit and while awaiting sale have been studied in some detail by the United States Department of Agriculture and discussed in a series of bulletins and other articles the titles of which may be found at the end of this chapter.

The practice recommended by Pennington is to bring the fowl into good condition by feeding clean grain mixed with buttermilk for from seven to fourteen days, then starve them for 24 hours in order that the intestinal tract may be as nearly empty as possible, and kill by cutting the jugular vein; then that part of the brain which controls the muscles holding the feathers in place is destroyed by a thrust of the knife, and the feathers are so loosened that they are easily pulled out. The cutting of the blood vessels in the proper way permits the blood to drain out of the carcass almost completely and the keeping quality is thus improved. After removal of feathers, and without removal of the entrails, the fowls should be hung by the feet on racks made entirely of metal and chilled by placing in rooms in which a temperature of about 32° F. is constantly maintained by means of mechanical refrigeration. Below 30° F. the flesh would become "frosted"; above 35° F. deterioration proceeds too rapidly to permit of long hauls to distant markets and the subsequent delays involved in the usual routine of city marketing. At 32° F. the time required for chilling is usually about 24 hours. The carcasses are then graded and packed, preferably in boxes holding 12 fowls each. The boxes should be lined with parchment paper and sometimes each fowl is wrapped separately. Separate cartons are sometimes used for extra high grade poultry. The packed poultry is shipped in refrigerator cars, either chilled or hard frozen. A refrigerator car as ordinarily loaded in the West contains 20,000 pounds of poultry. Bunkers filled with ice and salt maintain the low temperature of the car and its contents during transit.

Chemical analyses indicate that even when well handled and dry packed, the condition of dressed poultry after transportation varies appreciably with the differences in car temperatures ordinarily met. The best evidence of this is found in the development of ammonia as indicated in Fig. 17, which shows the percentages of ammoniacal nitrogen in the flesh of fowls other-

wise comparable which had been transported at different temperatures. The difference thus shown at the end of the railroad haul tends to continue and become greater throughout



FIG. 17. — Deterioration of poultry in transit at different temperatures.
U. S. Department of Agriculture.

the period that the fowls remain at the wholesale commission house or in the hands of the retailer, as is shown in Fig. 18, which, like Fig. 17, is taken from the bulletin by Pennington, Greenlee, *et al.*

Preservation is of course much more perfect when the fowls

are kept hard frozen and delivered to the consumer without thawing. The common practice of thawing frozen poultry before exposing it for sale is objectionable in that it introduces an opportunity for deterioration which is quite unnecessary,

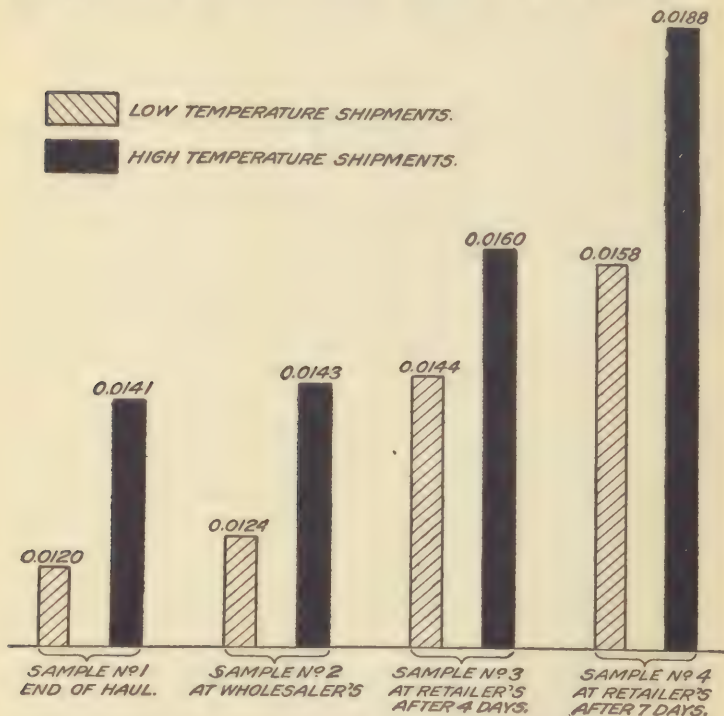


FIG. 18. — Deterioration of poultry during marketing period as affected by temperature. U. S. Department of Agriculture.

and would be avoided if consumers would learn to demand that the poultry be delivered to them in a solidly frozen condition.

The general composition of poultry is shown in the following table based on the data compiled by Atwater and Bryant.

TABLE 22. AVERAGE COMPOSITION OF POULTRY

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N $\times$ 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Chicken, broilers:									
Edible portion	3	—	74.8	21.5	21.6	2.5	—	1.1	492
As purchased	3	41.6	43.7	12.8	12.6	1.4	—	.7	289
Fowls:									
Edible portion	26	—	63.7	19.3	19.0	16.3	—	1.0	1016
As purchased	26	25.9	47.1	13.7	14.0	12.3	—	.7	751
Goose, young:									
Edible portion	1	—	46.7	16.3	16.3	36.2	—	.8	1774
As purchased	1	17.6	38.5	13.4	13.4	29.8	—	.7	1460
Turkey:									
Edible portion	3	—	55.5	21.1	20.6	22.9	—	1.0	1318
As purchased	3	22.7	42.4	16.1	15.7	18.4	—	.8	1043
Chicken gizzard, as purchased	1	—	72.5	24.7	24.7	1.4	—	1.4	505
Chicken heart, as purchased	1	—	72.0	20.7	21.1	5.5	—	1.4	600
Chicken liver, as purchased	1	—	69.3	22.4	—	4.2	2.4	1.7	621
Goose gizzard	1	—	73.8	19.6	19.4	5.8	—	1.0	593
Goose liver, as purchased .	1	—	62.6	16.6	—	15.0	3.7	1.2	1018

The nature of the nutrients is, so far as known, not different in any important respect from that of other meats. The chemical nature of the protein as shown by its products of hydrolysis has been studied in comparison with the flesh of widely different species by Osborne, whose results are tabulated farther on in this chapter. (Table 26.)

The light meat, such as breast, is composed of more tender fibers less firmly held together by connective tissue than is the dark meat, such as the leg muscle. Usually also the light meat contains less fat. For both these reasons it is apt to be somewhat more rapidly digested, at least in the stomach, and is therefore preferable for people having weak digestion. The impression

that light meat furnishes less of the substances which give rise to uric acid in the body does not seem to have been confirmed. Neither have we any evidence that the ash constituents differ in any important degree either as between light and dark meat or as between chicken meat and that of other animals.

Game

Formerly game was exceedingly abundant in the United States and played a large part in the diet of the people generally. Now the amount of game is so diminished and its sale is so restricted that it has become a negligible factor in the food supply, and need not be considered here further than to point out that the flesh of game animals and game birds does not differ in nutritive value to any important degree from the meats and poultry already considered.

Fish

The fish products of the United States as they leave the hands of the fishermen are estimated by the Bureau of Fisheries to approximate 2,169,000,000 pounds in weight, and \$58,000,000 in value annually. The total sum paid by consumers is of course much larger than that received by the fishermen.

Fish to be sold "fresh" may be sent directly to market or may be kept in cold storage either chilled to ice temperature or hard frozen. Recent experiments begun by C. S. Smith and continued by Perlzweig and Gies indicate that fresh fish may be preserved frozen, by the best cold storage processes, for at least two years without undergoing any important change.

The American analyses of the commercially important kinds of fresh fish are shown in Table 23.

TABLE 23. AVERAGE COMPOSITION OF FISH

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
FISH, FRESH									
Alewife, whole:									
Edible portion	2	—	74.4	19.4	19.2	4.9	—	1.5	552
As purchased	2	49.5	37.6	9.8	9.7	2.4	—	.8	276
Bass, black, whole:									
Edible portion	2	—	76.7	20.6	20.4	1.7	—	1.2	448
As purchased	2	54.8	34.6	9.3	9.3	.8	—	.5	201
Bass, red, whole:									
Edible portion	1	—	81.6	16.9	16.7	.5	—	1.2	327
As purchased	1	63.5	29.8	6.2	6.1	.2	—	.4	121
Bass, sea, whole:									
Edible portion	1	—	79.3	19.8	18.8	.5	—	1.4	380
As purchased	1	56.1	34.8	8.7	8.3	.2	—	.6	166
Bass, striped, whole, edible portion	6	—	77.7	18.6	18.3	2.8	—	1.2	452
Bass, striped, entrails removed, as purchased	1	51.2	37.4	8.8	8.7	2.2	—	.5	249
Blackfish, whole:									
Edible portion	4	—	79.1	18.7	18.5	1.3	—	1.1	393
As purchased	2	60.2	31.4	7.4	7.3	.7	—	.4	163
Blackfish, entrails removed, as purchased	2	55.7	35.0	8.4	8.3	.5	—	.5	173
Bluefish, entrails removed:									
Edible portion	1	—	78.5	19.4	19.0	1.2	—	1.3	401
As purchased	1	48.6	40.3	10.0	9.8	.6	—	.7	206
Buffalo fish, entrails removed:									
Edible portion	1	—	78.6	18.0	17.9	2.3	—	1.2	430
As purchased	1	52.5	37.3	8.5	8.5	1.1	—	.6	205
Butter-fish, whole:									
Edible portion	1	—	70.0	18.0	17.8	11.0	—	1.2	776
As purchased	1	42.8	40.1	10.3	10.2	6.3	—	.6	444
Catfish:									
Edible portion	1	—	64.1	14.4	14.4	20.6	—	.9	1102
As purchased	1	19.4	51.7	11.6	11.6	16.6	—	.7	888

TABLE 23. AVERAGE COMPOSITION OF FISH—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N $\times$ 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
FISH, FRESH									
Cod, dressed, as purchased	3	29.9	58.5	11.1	10.6	.2	—	.8	210
Cod, sections, edible portion	3	—	82.5	16.7	16.3	.3	—	.9	315
Cod, steaks:									
Edible portion	1	—	79.7	18.7	18.6	.5	—	1.2	370
As purchased	1	9.2	72.4	17.0	16.9	.5	—	1.0	329
Cusk, entrails removed:									
Edible portion	1	—	82.0	17.0	16.9	.2	—	.9	317
As purchased	1	40.3	49.0	10.1	10.1	.1	—	.5	188
Eels, salt water, head, skin, and entrails removed:									
Edible portion	2	—	71.6	18.6	18.3	9.1	—	1.0	709
As purchased	2	20.2	57.2	14.8	14.6	7.2	—	.8	562
Flounder, whole:									
Edible portion	3	—	84.2	14.2	13.9	.6	—	1.3	282
As purchased	2	61.5	32.6	5.4	5.1	.3	—	.5	110
Flounder, entrails removed, as purchased	1	57.0	35.8	6.4	6.3	.3	—	.6	128
Haddock, entrails removed:									
Edible portion	4	—	81.7	17.2	16.8	.3	—	1.2	324
As purchased	4	51.0	40.0	8.4	8.2	.2	—	.6	160
Hake, entrails removed:									
Edible portion	1	—	83.1	15.4	15.2	.7	—	1.0	308
As purchased	1	52.5	39.5	7.3	7.2	.3	—	.5	145
Halibut, steaks or sections:									
Edible portion	3	—	75.4	18.6	18.4	5.2	—	1.0	550
As purchased	3	17.7	61.9	15.3	15.1	4.4	—	.9	457
Herring, whole:									
Edible portion	2	—	72.5	19.5	18.9	7.1	—	1.5	644
As purchased	2	42.6	41.7	11.2	10.9	3.9	—	.9	362
Mackerel, whole:									
Edible portion	6	—	73.4	18.7	18.3	7.1	—	1.2	629
As purchased	5	44.7	40.4	10.2	10.0	4.2	—	.7	356
Mackerel, entrails removed, as purchased	1	40.7	43.7	11.6	11.4	3.5	—	.7	353

TABLE 23. AVERAGE COMPOSITION OF FISH—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N $\times$ 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
FISH, FRESH									
Mullet, whole:									
Edible portion	1	—	74.9	19.5	19.3	4.6	—	1.2	542
As purchased	1	57.9	31.5	8.2	8.1	2.0	—	.5	230
Muskellunge, whole:									
Edible portion	1	—	76.3	20.2	19.6	2.5	—	1.6	409
As purchased	1	40.2	38.7	10.2	10.0	1.3	—	.8	238
Perch, white, whole, edible portion	2	—	75.7	19.3	19.1	4.0	—	1.2	514
Perch, yellow, whole:									
Edible portion	2	—	79.3	18.7	18.7	.8	—	1.2	372
As purchased	1	62.7	30.0	6.6	6.7	.2	—	.4	127
Perch, yellow, dressed, as purchased	1	35.1	50.7	12.8	12.6	.7	—	.9	261
Pickrel, pike, whole:									
Edible portion	3	—	70.8	18.7	18.6	.5	—	1.1	360
As purchased	2	47.1	42.2	9.9	9.9	.2	—	.6	188
Pickrel, pike, entrails removed, as purchased . .	1	42.7	45.7	10.7	10.7	.3	—	.6	206
Pollock, dressed:									
Edible portion	1	—	76.0	21.6	21.7	.8	—	1.5	425
As purchased	1	28.5	54.3	15.4	15.5	.6	—	1.1	304
Porgy, whole:									
Edible portion	3	—	75.0	18.6	18.5	5.1	—	1.4	546
As purchased	3	60.0	29.9	7.4	7.4	2.1	—	.6	220
Salmon, whole:									
Edible portion	6	—	64.6	22.0	21.2	12.8	—	1.4	922
As purchased	4	34.9	40.9	15.3	14.4	8.9	—	.9	642
Salmon, entrails removed, as purchased:									
		20.5	48.1	13.8	13.5	8.1	—	.8	582
Shad, whole:									
Edible portion	7	—	70.6	18.8	18.6	9.5	—	1.3	727
As purchased	7	50.1	35.2	9.4	9.2	4.8	—	.7	367
Shad roe, as purchased . .	1	—	71.2	20.9	—	3.8	2.6	1.5	582
Sheepshead, edible portion	2	—	75.6	20.1	19.5	3.7	—	1.2	516

TABLE 23. AVERAGE COMPOSITION OF FISH Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N $\times$ 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
FISH, FRESH									
Sheepshead, entrails removed, as purchased	1	56.6	31.2	9.0	8.8	2.9	—	.5	282
Smelt, whole:									
Edible portion	2	—	79.2	17.6	17.3	1.8	—	1.7	393
As purchased	2	41.9	46.1	10.1	10.0	1.0	—	1.0	224
Spanish mackerel, whole:									
Edible portion	1	—	68.1	21.5	21.0	9.4	—	1.5	774
As purchased	1	34.6	44.5	14.1	13.7	6.2	—	1.0	509
Sturgeon, anterior sections:									
Edible portion	1	—	78.7	18.1	18.0	1.0	—	1.4	406
As purchased	1	14.4	67.4	15.1	15.4	1.6	—	1.2	339
Tomcod, whole:									
Edible portion	1	—	81.5	17.2	17.1	.4	—	1.0	328
As purchased	1	59.9	32.7	6.9	6.8	.2	—	.4	133
Trout, brook, whole:									
Edible portion	3	—	77.8	19.2	18.9	2.1	—	1.2	434
As purchased	3	48.1	40.4	9.9	9.8	1.1	—	.6	225
Trout, salmon or lake:									
Edible portion	2	—	70.8	17.8	17.7	10.3	—	1.2	743
As purchased	2	48.5	36.6	9.1	9.2	5.1	—	6	373
Turbot:									
Edible portion	1	—	71.4	14.8	12.0	14.4	—	1.3	857
As purchased	1	47.7	37.3	7.7	6.8	7.5	—	.7	446
Weakfish, whole:									
Edible portion	1	—	70.0	17.8	17.4	2.4	—	1.2	421
As purchased	1	51.9	38.0	8.6	8.4	1.1	—	.6	201
Whitefish, whole:									
Edible portion	1	—	69.8	22.9	22.1	6.5	—	1.6	680
As purchased	1	53.5	32.5	10.6	10.3	3.0	—	.7	315
AMPHIBIA									
Frogs' legs:									
Edible portion	2	—	83.7	15.5	15.1	.2	—	1.0	289
As purchased	2	32.0	56.9	10.5	10.3	.1	—	.7	194

Preserved Fish

Many kinds of fish are preserved in large quantities by drying, salting, smoking, canning, or by combinations of these processes. As illustrative of these industries the preparation of salt codfish, canned salmon, and sardines in oil will be outlined.

Preparation of salt cod. This is a New England industry centering at Gloucester, Mass. The annual product (including cusk, haddock, hake, and pollock which are caught and handled with the cod) is estimated to represent a catch of about 225,000,000 pounds. In a recent bulletin of the Bureau of Chemistry, United States Department of Agriculture, Bitting describes the process as follows:

The cod are separated into three classes, snappers, medium, and large, according to their size. All codfish less than 16 inches from the curve of the nape to the hollow of the tail are designated as snappers; those more than 16 but under 22 inches are called medium, and those above 22 inches are rated as large. The codfish generally run — snappers 4 per cent, medium 41 per cent, and large 55 per cent. The cusk and hake are generally divided into two sizes, the snappers under 19 inches and the large above that. Each class is weighed and kept separate, being examined for any evidence of spoilage as they are pitched out. . . .

The curing of salt fish depends upon drying, and this is accomplished in three ways — by the use of salt, by pressure, and by exposure to the air, either in the open air or in a drier. In this country all three agents are employed, as it is not possible to dry the fish in the air alone, as is done in certain parts of Norway.

Salt acts as a drier as well as a preservative, as it abstracts moisture wherever it comes in contact with the tissue, whether this be in the kench in the boat or in the butt at the factory. In the strictly full-pickle fish (that is, fresh fish placed in the butt) the maximum effect of drying by means of salt is accomplished. All the water abstracted in making pickle is so much drying. Kenching and air drying are necessary to complete the operation, though the amount of water abstracted by the latter operations is not so great as is generally supposed. In the "kench cure" there is a combination of salting and pressure. . . .

A very large proportion of the fish is cured by a combination of these two processes, being salted and kenched on board the boat and the work com-

pleted in pickle at the factory. One of the advantages of the pickle cure is that the fish can be handled at all seasons and at such a rate as the trade may demand. For the slack-salted fish the salt is used as a preservative and the drying is accomplished by pressure and in the air. This can be done only when the weather is favorable.

The more fully the drying is done by salt or by pressure, the less time is required on the flakes. Those dried for domestic consumption are not nearly so dry as those packed for export trade. In the former class the moisture content is usually between 43 and 51 per cent, while in the latter it is between 28 and 35 per cent. . . .

The fish are dried on flakes and the drying yard is known as the flake yard. The flake consists of a lattice bed about 8 feet wide, 30 inches high, and as long as the requirements may demand. The lattice used on this bed is made of triangular strips 1 inch on the base, and these are placed about 3 inches apart. The fish therefore rest upon a sharp edge about every 4 inches. This is for the purpose of giving the maximum circulation of air about the fish. One double-deck flake yard was seen, the space between decks being 18 inches.

At regular intervals along the flakes, crosspieces are provided over which to stretch a canvas to protect the fish from sunburn during hot weather. Boxes or coops are also provided to cover the fish during rains and at night. . . .

The fish are spread out carefully on the flakes with the face side up, and the drying is continued as long as may be necessary for the particular grade of fish. The full-pickle fish are dried for the shortest period, as they cannot be skinned readily if too dry, and, furthermore, the trade seems to desire fish which are moist and not too hard, and these retain practically 50 per cent of their water. If the sun is fairly warm and there is a good breeze, the drying can be accomplished in about ten hours as the minimum time, but this may be greatly increased with unfavorable weather conditions. Only one drying is usual for the full-cured fish.

The slack-salted fish are generally dried for two days, kenched for two or three days to "sweat" them, then placed on the flakes again for one day. Porto Rican or hard-dried fish are dried for three days, "sweated" for two days, and then again dried for two days. The object of the "sweating" is to bring the moisture out of the interior of the fish. The drying on the flakes removes the moisture from the surface and crystallizes the salt, but to get the moisture out of the center of the meat the fish must be piled in the kench, where the dry salt takes up some of the remaining moisture, so that the second drying on the flakes has a greater effect. The full-pickle fish lose about 9 per cent of their weight in drying on the flakes. When

cured, they retain about 50 per cent of their moisture, the slack-salted retain 35 to 40 per cent, and the hard-dried from 25 to 30 per cent.

The fish are taken to the skinning department according to the orders to be filled. If the fish are to be put up as "absolutely boneless," then the fins are pulled out and the skin pulled off. The skin is started at the napes and pulled in toward the middle of the back and then pulled toward the tail. If the fish has been properly cured, the skin can be stripped off clean without tearing the flesh. If it has been sunburned, the skin will not hang together well. After the back has been skinned the fish is turned over and the dark lining membrane of the napes is stripped forward so that the whole fish is clean. The remaining portion of the backbone is cut out and the fish is passed to the bone pickers, who remove with forceps the ribs and any pieces of bone left in the body. If the fish are to be packed as so-called "boneless," then the fins are only cut off and the thick part of the backbone cut out closely, the small pieces of the fins, ribs, and backbone being allowed to remain. The term "boneless" as used in the trade is hardly appropriate and should be changed for one more nearly descriptive of the real conditions.

From bone picking to cutting is a short step. The table at which this is done is made of boards with openings between them at regular intervals. The fish are laid on the cutting table so that the best parts come between the openings. A half dozen pieces or more may be stretched out at a time across these openings, then a long-bladed knife is swept through them and they are ready to be packed into fish cakes, etc. A trough or miter box is also used for securing the same result.

The pieces of fish are passed to girls, who sort them and weigh out exactly a pound or two pounds, whatever the cake or package is to be. Two good slices are selected to make the outside of the packages, and short or narrow strips to make up the middle part. . . . The mold is pressed tightly by foot power, held for a few seconds, and a twine string tied securely around near each end. . . . The package is completed by wrapping first in paraffined paper and then in the labeled wrapper.

Preparation of canned salmon. The salmon of the North Pacific coast has now become one of the most important fishery products. It is said that in the Northwest the catching and packing of salmon is an enterprise second only to the lumber industry in size. The output in 1911 amounted to 290,000,000 cans. The canned salmon put up in this region is used throughout America and also to a considerable extent abroad. The outline of the industry which follows is based upon a paper by

Loomis of the Bureau of Chemistry, United States Department of Agriculture, presented at the Eighth International Congress of Applied Chemistry.

There are five principal varieties of salmon packed along the Pacific coast, each of which is known by several names, depending upon the locality in which it is caught. The fish with reddest flesh and most oil are usually preferred by consumers, the following being the commonly accepted order of preference: (1) Red salmon, sockeye, or blueback; (2) chinook, king, or spring salmon; (3) medium red salmon, coho, or silverside; (4) humpback or pink salmon; (5) chum or dog salmon.

The salmon spend most of their lives in the sea but spawn in the fresh water of the rivers. They are caught in seines and traps of various forms, placed along the shores of the mainland or islands at points which the large schools of fish pass on their way from the ocean to the rivers. As many as 50,000 salmon are sometimes taken in a trap at once. The sockeye salmon weighs usually from 5 to 10 pounds, while the other varieties are larger, the chinook being largest and averaging about 30 pounds.

At the cannery the fish are unloaded and carried by conveyor to a machine which removes the heads, tails, fins, and entrails. The fish are then cleaned, washed, and sliced transversely into pieces of the right size to fit the cans. Salt is first placed in the cans, then the sections of salmon are packed in, the can covers put on, and the whole heated in a steam retort for one half hour, sealed while hot, tested for leaks, heated again at 240° F. to sterilize the contents, and the cans finally retested, cleaned, lacquered, and labeled. The details vary somewhat, depending upon whether a soldered can or a so-called sanitary can is used.

The salmon canning industry is regulated by the Bureau of Chemistry under the Food and Drugs Act and by the Bureau of Fisheries under the provisions of the Alaska Fisheries Law. Loomis finds that the methods in use are generally adapted to the production of a fresh, clean, and high-grade product and

that there is little if any attempt at misbranding, the cans being generally labeled to show the variety of salmon contained in them.

The sardine industry. The fish packed in France under the name sardine is the *Clupea pilchardus*; while the Maine sardine is the *Clupea harengus*. In the opinion of the Bureau of Fisheries and of the United States Department of Agriculture the name sardine is equally applicable to either species. Sardines need not therefore be labeled to show their origin, but of course must not "purport to be a foreign product when not so." Also if packed in any other than olive oil, the fact must be stated. French sardines are usually packed with much care in olive oil and sold at a high price. Maine sardines are usually handled rapidly in large quantities, packed in cottonseed oil and sold at such low prices as to make them an economical food. The following outline of the industry as carried on in Maine is taken from reports made by Buswell to the Maine Experiment Station in 1911, and by Hanson to the Eighth International Congress of Applied Chemistry in 1912.

Sardines are canned in about fifty-five factories along the Maine coast, the total annual output being between 125,000,000 and 200,000,000 cans valued at from \$5,000,000 to \$7,000,000 according to the season.

The fish are trapped in weirs and are taken by seining the weir shortly before low tide. As many as three hundred hogsheads of herring have been caught in a single weir at one time.

At the factory they are scooped into tubs with scoop nets or shovels, and hoisted to the sluicing troughs, which run on an incline either through a separator to the pickle tanks or directly to the tanks without separating. The separator is a simple device for separating those to be packed in oil — 3 to 7 inches in length — from the larger ones which are to be packed in mustard sauce. It consists of an inclined revolving drum made up of hoops of steel pipe placed closer together at the upper than at the lower end. As the fish are sluiced through the separator the smaller ones drop through the openings at the upper end while those larger pass on to the lower end. From the separator the fish fall into sluices which convey them to the pickle tanks. The lower end of these sluices is made of coarse wire netting which allows the water to drain off and prevents the dilution of the pickle.

The pickle tanks are of wood and hold about three hogsheads. They are filled about one third full with a 90 to 95 per cent saturated salt solution. This solution is strong enough to float the fish. If it becomes so weak — due to the loss of the salt taken up by the fish — that the fish sink, it is considered a sign that they are beginning to take up water, which is most undesirable. The length of time the fish are left in the pickle is variable, but the most common practice is to leave the fish in the pickle from one and one half to three hours. The object of the pickling is to toughen the fish and give flavor. Fat fish take the salt much less readily than do lean fish, hence require a longer time in the pickle.

From the pickle room the fish are sluiced or carried in baskets to the flaking room where they are laid in rows on wire trays or flakes. This is usually done by machine, but sometimes by hand. The flaking machine when properly operated does the work much faster than it can be done by hand.

The flakes of fish are next placed in racks running on rollers and these are pushed into the steam boxes where they are cooked with live steam for from 8 to 15 minutes. The object of steaming is to cook the fish. A well-cooked fish should not show blood along the backbone.

After steaming the fish are dried, either in air driers or in ovens. The air driers are in general of two types: First, a long low-ceiling room with a large fan at one end which blows heated air over the racks of fish; second, a circular chamber with a fan in the center. From the first type the dried fish are taken out by a door at the fan end of the drier while at the same time wet fish are being put in at the opposite end. Two or three hours are required for drying. In the second type the floor of the chamber revolves slowly so that as they pass a certain point the racks of dry fish are taken off and wet fish put on.

There are two types of ovens, the older or reel oven and the track oven. The reel oven is of brick having a large reel revolving over a hard coal fire. As the pans which hang from the arms of the reel come to the front of the oven the flakes of dried fish are taken off and wet fish put on. The time of one revolution varies with the heat of the fire and the size of the fish, but as a rule about 20 minutes are required to dry the fish thoroughly. The other type of oven has steel tracks arranged so that the racks of flakes can be pushed in over the fire; 15 to 30 minutes are required to dry the fish in this kind of an oven.

The dried fish are next distributed to the packing tables, where they are beheaded with shears and packed in tin boxes, holding 4 or 11 ounces of fish. In general the small fish are packed in oil in the 4-ounce boxes, the larger fish in mustard sauce in 11-ounce boxes. Fish of intermediate size are brought to the proper length for the smaller boxes by cutting off the anterior portions.

(These anterior sections, which of course are just as good as the part used for canning, furnish the material for the manufacture of "deviled sardine.")

The cans then go to the sealing machine, where the covers are sealed on, after which they are "bathed." The bath is a rectangular steel tank about three and one half feet deep, filled with water and heated by a perforated steam coil in the bottom. The object of "bathing" is to sterilize the contents of the can and to soften the bones. To accomplish this the four ounce cans are bathed from one and one quarter to two hours, and the eleven ounce cans from one and one half to three hours. Long bathing tends to "chowder" the fish.

The sardines packed in oil in the four ounce cans are called by the trade "quarter oils." A few are packed in mustard sauce in the same size cans and these are called "quarter mustards." Most of the fish packed in mustard sauce, however, are packed in the 11 ounce size and these are called "three-quarter mustards."

Composition of preserved fish. The results of American analyses of canned, dried, salted, and smoked fish as compiled by Atwater and Bryant are as follows:

TABLE 24. COMPOSITION OF PRESERVED FISH

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cals.
FISH, PRESERVED AND CANNED									
Cod, salt, "boneless," as purchased . . .	1	1.6	54.8	27.7	28.6	.3	—	14.7	515
Haddock, smoked:									
Edible portion . . .	1	—	72.5	3.3	23.7	.2	—	3.6	431
As purchased . . .	1	32.2	49.2	15.8	16.1	.1	—	2.4	291
Halibut, smoked:									
Edible portion . . .	2	—	49.4	20.7	20.6	15.0	— ¹	15.0	988
As purchased . . .	2	27.0	46.0	19.3	19.1	14.0	—	13.9	922
Herring, smoked:									
Edible portion . . .	1	—	34.6	36.9	36.4	15.8	— ²	13.2	1315
As purchased . . .	1	44.4	19.2	20.5	20.2	8.8	—	7.4	731

¹One sample contained 12.1 per cent common salt.

²Contained 11.7 per cent common salt.

TABLE 24. COMPOSITION OF PRESERVED FISH—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
FISH, PRESERVED AND CANNED		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Mackerel, salt, entrails removed:									
Edible portion . . .	1	—	42.2	21.1	22.0	22.6	— ¹	13.2	1305
As purchased . . .	1	22.9	32.5	16.3	17.0	17.4	—	10.2	1005
Mackerel, salt, canned, as purchased . . .	1	—	68.2	19.6	19.9	8.7	—	3.2	711
Mackerel, salt, canned in oil:									
Edible portion . . .	1	—	58.3	25.4	23.5	14.1	—	4.1	1037
As purchased . . .	1	² 31.5	39.9	17.4	16.1	9.7	—	2.8	722
Mackerel, salt, dressed:									
Edible portion . . .	2	—	43.4	17.3	17.3	26.4	— ³	12.9	1392
As purchased . . .	2	19.7	34.8	13.9	13.9	21.2	—	10.4	1118
Pilchard in tomatoes, canned, Russia, as purchased . . .	1	—	52.7	27.9	27.5	15.8	—	4.0	1152
Salmon, canned:									
Edible portion . . .	7	—	63.5	21.8	21.8	12.1	—	2.6	889
As purchased . . .	3	14.2	56.8	19.5	19.5	7.5	—	2.0	660
Sardines, canned:									
Edible portion . . .	2	—	52.3	23.0	22.4	19.7	—	5.6	1221
As purchased . . .	1	² 5.0	53.6	23.7	24.0	12.1	—	5.3	924
Sturgeon, dried, Russia:									
Edible portion . . .	1	—	50.6	31.8	32.2	9.6	—	7.6	969
As purchased . . .	1	12.7	44.1	27.8	28.1	8.4	—	6.7	848
Sturgeon, caviare, pressed, Russian, as purchased	1	—	38.1	30.0	—	19.7	7.6	4.6	1487
Tunney, as purchased .	1	—	72.7	21.7	21.5	4.1	—	1.7	560
Tunney, canned in oil, Russia:									
Edible portion . . .	1	—	51.3	23.8	—	20.0	0.6	4.3	1260
As purchased . . .	1	16.7	42.7	20.3	—	16.7	—	3.6	1400

¹ Contained 9.2 per cent common salt.² Refuse, oil.³ Contained 10.4 per cent common salt.

Shellfish

The principal shellfish used for food are divisible into two classes: (1) mollusks, including oysters, clams, mussels, and scallops; (2) crustaceans, including lobsters, crabs, shrimps, and crawfish.

Of all of these the oyster is by far the most important as a factor in the general food supply.

It is estimated that the oyster crop of the United States (representing about two thirds of the world's supply) approximates 25,000,000 bushels annually, valued at about \$20,000,000. The total amount paid at retail would of course be much larger. The shores of Long Island and of Chesapeake Bay produce oysters abundantly. According to statistics collected by Stiles, the chief oyster-producing states are, in order of rank: New York, Virginia, Connecticut, Maryland, New Jersey, Rhode Island, Louisiana, Mississippi. A considerable proportion of the oyster crop, perhaps one fifth, is preserved by canning. The oyster-canning industry grew up around Baltimore, but is now carried on to an even larger extent in some of the more Southern states, where there are areas well suited to oyster culture but not readily accessible to the large markets.

Although still classified with the fisheries, the oyster industry is rapidly becoming a kind of farming. Submerged lands suitable for oyster culture are either owned or rented from the state, and many people devote themselves exclusively to the care of these oyster farms, which in some cases are natural oyster beds which have been conserved and in other cases are the result of artificial planting. The oyster reproduces by eggs which on hatching yield free-swimming larvæ, but when about two weeks old the young oysters have secreted shells of sufficient weight to cause them to sink and they then "set" on any object with which they come in contact, and thereafter are stationary. By the end of the first season the young oyster is from one to



FIG. 19. — Seed oysters.

two centimeters, or about one half to three fourths of an inch in diameter and at this stage in their development are often sold as " seed oysters " (Fig. 19) to be replanted in other beds. This transplanting of oysters is a matter of growing importance and appears to make possible a great development of the industry, since there are large areas on both the Atlantic and Pacific coasts, as well as in other countries, where the conditions are unfavorable for spawning but entirely suitable for the raising of transplanted oysters. The rate of growth of the oyster is dependent upon its environment, but in general it is expected that the oysters will be marketed when from three to five years old.

It is partly for the sanitary protection of the shellfish grounds of the estuaries and inland waters that the state and federal governments are now taking steps to prevent or regulate the discharge of raw sewage into rivers and harbors.

The feeding habits of oysters, clams, and mussels make it probable that they will contain considerable numbers of bacteria of the types characteristic of the waters in which they live. Hence when these shellfish are taken from (or have been kept in) sewage-polluted waters, they may easily contain bacteria of the intestinal types and thus may become carriers of typhoid fever as well as less serious intestinal disorders. This was first clearly demonstrated by Conn, in the investigation of an epidemic of typhoid among the students of Wesleyan University in 1894. The epidemic was confined to members of the various college fraternities which had held banquets in their several houses, but all on the same evening. Each of these banquets had included raw oysters and all the oysters came from one dealer and had been " floated " or " fattened " at the mouth of a stream. This stream was found to be highly polluted, and further investigation showed that in one house near by there were two cases of typhoid the discharges of which passed through the house drain into the stream without disinfection. There

was left no room for doubt that the typhoid bacteria passed from the patients in the house near the stream to the oysters and so to the students at the banquet. In 1902 there occurred simultaneous outbreaks of typhoid fever at Winchester and at Southampton, England, which were traced to contaminated oysters from a common source. In 1912 two epidemics of typhoid and other intestinal disorders were clearly traced by Stiles¹ to oysters obtained from a dealer who was accustomed to store his shellfish in water which on investigation was found to be contaminated. As Prescott and Winslow point out:² "It should be noted that it is unfortunately not only raw shellfish which are responsible for the spread of disease. Most of the processes of cooking to which these foods are subjected are insufficient to destroy pathogenic germs." These authors quote results showing that, with steamed clams, the bacteria present could not be destroyed except by a temperature high enough and prolonged enough to ruin the clams for eating and that oyster stew, fried oysters, and fancy roast oysters may still contain active bacteria of the types indicative of sewage pollution. Clams in chowder, on the other hand, were found to be practically sterilized.

When shellfish are carelessly opened and handled, they may receive additional contamination in the process. Stiles, in 1911, found enormously greater numbers of bacteria in the "shucked" than in the corresponding "shell" oysters.

Gorham³ has found that oysters taken from the same beds show much less contamination in winter than in summer. He believes that during the cold weather the oysters assume a condition of rest or hibernation, during which the process of feeding is suspended. In such a condition no organisms would be taken in from the outside water and those within the oyster

¹ See references at the end of the chapter.

² *Elements of Water Bacteriology* (3d ed.), page 248.

³ See references at the end of the chapter.

are gradually destroyed. These observations upon seasonal variations were made with oysters taken from Narragansett Bay; whether the same holds true in the warmer waters farther south does not appear to have been determined. It would seem only a reasonable precaution not to eat shellfish taken from contaminated waters at any season of the year; at least not until after such thorough cooking as to insure the death of any bacteria present.

Oysters are often kept for a time after gathering, on rafts constructed with false bottoms where they remain immersed in the water. This is called "floating." Except where the practice is forbidden by law, it is common for the dealers to "float" oysters in waters of a less salt content than that in which they were grown, with the result that the fresher water enters the oyster, increasing its plumpness and weight and giving it a whiter appearance. If the water in which the oysters are floated is less pure than that in which they were grown, the danger of disease bacteria in the oyster is of course increased, and *vice versa*. How long it would be necessary to float polluted oysters in pure water in order to make them safe cannot be stated with any degree of certainty at the present time.

The composition of the principal shellfish used for food is shown in Table 25, in which the percentages of nutrients are those given by Atwater and Bryant and the fuel values are recalculated as explained in earlier chapters.

TABLE 25. AVERAGE COMPOSITION OF SHELLFISH

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
SHELLFISH, ETC., FRESH									
Clams, long, in shell :									
Edible portion . . .	4	—	85.8	8.6	—	1.0	2.0	2.6	233
As purchased . . .	4	41.9	49.9	5.0	—	.6	1.1	1.5	135
Clams, round, in shell :									
Edible portion . . .	1	—	86.2	6.5	—	.4	4.2	2.7	210
As purchased . . .	1	67.5	28.0	2.1	—	.1	1.4	.9	68
Clams, round, removed from shell, as purchased .	1	—	80.8	10.6	—	1.1	5.2	2.3	332
Crabs, hardshell, whole :									
Edible portion . . .	1	—	77.1	16.6	—	2.0	1.2	3.1	405
As purchased . . .	1	52.4	36.7	7.9	—	.9	.6	1.5	191
Crayfish, abdomen, whole :									
Edible portion . . .	1	—	81.2	16.0	—	.5	1.0	1.3	329
As purchased . . .	1	86.6	10.9	2.1	—	.1	.1	.2	44
Lobster, whole :									
Edible portion . . .	5	—	79.2	16.4	—	1.8	.4	2.2	379
As purchased . . .	5	61.7	30.7	5.9	—	.7	.2	.8	139
Mussels, in shell :									
Edible portion . . .	1	—	84.2	8.7	—	1.1	4.1	1.9	277
As purchased . . .	1	46.7	44.9	4.6	—	.6	2.2	1.0	148
Oysters, in shell :									
Edible portion . . .	34	—	86.9	6.2	—	1.2	3.7	2.0	228
As purchased . . .	34	81.4	16.1	1.2	—	.2	.7	.4	43
Oysters, solids, as purchased . . .	9	—	88.3	6.0	—	1.3	3.3	1.1	222
Scallops, as purchased . .	2	—	80.3	14.8	—	.1	3.4	1.4	334
Terrapin :									
Edible portion . . .	1	—	74.5	21.2	21.0	3.5	—	1.0	528
As purchased . . .	1	75.4	18.3	5.2	5.2	.9	—	.2	131
Turtle, green, whole :									
Edible portion . . .	1	—	79.8	19.8	18.5	.5	—	1.2	380
As purchased . . .	1	76.0	19.2	4.7	4.4	.1	—	.3	89

TABLE 25. AVERAGE COMPOSITION OF SHELLFISH—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N X 6.25	By difference				
SHELLFISH, ETC., CANNED		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Clams, long, as purchased	1	—	84.5	0.0	—	1.3	2.0	2.3	260
Clams, round, as purchased	1	—	82.0	10.5	—	.8	3.0	2.8	277
Crabs, as purchased . . .	2	—	80.0	15.8	—	1.5	.7	2.0	360
Lobster, as purchased . . .	2	—	77.8	18.1	—	1.1	.5	2.5	382
Oysters, as purchased . . .	4	—	83.4	8.8	—	2.4	3.0	1.5	328
Shrimp, as purchased . . .	1	—	70.8	25.4	—	1.0	.2	2.0	505

Ash constituents of oysters. The fact that the oyster secretes such a large amount of calcium in its shell suggests that the edible portion may be relatively rich in calcium as compared with other flesh foods, which, as we have seen, are strikingly poor in this element.

According to Albu and Neuberg the edible portion of the oyster is strikingly rich in calcium, but an investigation now in progress shows the following preliminary results:

	PER CENT
Calcium oxide	0.06
Magnesium oxide	0.06
Potassium oxide	0.06
Sodium oxide	0.59
Phosphorous pentoxide	0.37
Chlorine	0.67
Sulphur	0.18

This analysis shows a calcium content somewhat above that of meat but much below that of milk, and a preponderance of acid-forming elements as great as that found in lean meats.

Comparison of Poultry, Fish, and Shellfish with Other Flesh Foods

Attention has been called to the similarity of all these flesh foods and to the fact that the differences in general composition are chiefly attributable to varying fat content.

That there is also a general similarity in the structure of the proteins of shellfish, fish, and fowl and of ordinary meat protein such as beef is shown by the following table based on the work of Osborne:

TABLE 26. PERCENTAGES OF AMINO ACIDS FROM THE FLESH OF WIDELY DIFFERENT SPECIES

	SCALLOPS	HALIBUT	CHICKEN	BEEF
Glycin	0.00	0.00	0.68	2.06
Alanin			2.28	3.72
Valin		0.79		0.81
Leucin	8.78	10.33	11.19	11.65
Prolin	2.28	3.17	4.74	5.82
Phenylalanin	4.90	3.04	3.53	3.15
Aspartic acid	3.47	2.73	3.21	4.51
Glutamic acid	14.88	10.13	16.48	15.49
Tyrosin	1.95	2.39	2.16	2.20
Arginin	7.38	6.34	6.50	7.47
Histidin	2.02	2.55	2.47	1.76
Lysin	5.77	7.45	7.24	7.59
Ammonia	1.08	1.33	1.67	1.07
Tryptophan	present	present	present	present
Summation	52.51	50.25	62.15	67.30

The digestibility of fish and poultry was studied quantitatively by Milner in a series of experiments in which the coefficient of digestibility was determined with four different men for each of the four foods, canned salmon, fresh cod, canned chicken, and roast duck. The average coefficients of digestibility found were as follows:

	PROTEIN	FAT
Salmon	96.23	97.01
Cod	95.93	97.40
Chicken	96.74 ¹	97.13
Duck	94.66	97.32

The digestibility as thus determined is seen to be approximately equal to that of meats and appreciably higher than that of average mixed diet.

While these coefficients represent digestibility in the only sense in which it can be measured quantitatively, it is well known that the term digestibility is also used to indicate the relative ease and comfort with which foods are digested and the readiness with which gastric digestion is completed as evidenced by the time elapsing between the eating of the food and its entire passage from the stomach into the intestine. In these respects oysters, lean fish, and chicken are held to be even more digestible than lean beef, while fat fish, duck, goose, lobsters, and crabs are held to be of about the same order of digestibility with ham and pork. (See for instance the Table of Comparative Digestibility in Gilman Thompson's *Practical Dietetics*.)

Place in the diet. From most standpoints poultry, fish, and shellfish may be regarded as interchangeable with the ordinary meats. The comparative economy of these different types of flesh food varies widely with locality and season. While game has become so scarce and costly as to be no longer an important factor in the food supply, the prices of poultry, fish, and shellfish appear at present to be rising less rapidly on the whole than the price of beef. The breaking up of the great cattle ranges into small cultivated farms naturally tends toward

¹One of the four experiments with chicken gave a result (93.13) so much lower than the others as to suggest that it may not have been representative. If this result be omitted, the average becomes 97.93.

a relative (perhaps not absolute) decrease in beef production and an increase (both absolute and relative) in poultry culture. Oyster culture is becoming systematized so that, while oysters will doubtless remain an expensive food, the supply will probably increase. The fishery industries are also capable of great development both by improved methods of handling the species now regarded as important and by utilizing as food the flesh of species which in the past have been neglected. Thus it is said that a few years ago sturgeon was so little prized as food that much of it was used as fertilizer, while now smoked sturgeon is in good demand, and that still more recently the garfish, formerly regarded merely as a pest, has begun to find a market as a food fish.

Since in the nature of the case the meat production of the country cannot be greatly increased except at the cost of a restricted output of other farm crops, we may anticipate a constantly increasing tendency towards better conservation and more economical utilization of the fishery products as food.

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CHAPTER VIII

GRAIN PRODUCTS

THE cereals are much the most important of the grains used as food for man, but since a few grains not belonging botanically to the cereals are used for food (and also because "cereals" suggests only breakfast cereals to some readers) the term "grain products" is here used as the general designation to cover barley, buckwheat, corn or maize, oats, rice, rye, and wheat, and the various mill products made from them.

The raising of grain plays a very large part in the agriculture of nearly all countries, and for the great majority of people grain products furnish more nutriment than does any other type of food material. Langworthy estimates from the results of about 400 dietary studies that grain products furnish 43.0 per cent of the protein, 9.1 per cent of the fat, and 61.8 per cent of the carbohydrates of the average American dietary. Thus the quantities eaten furnish more carbohydrate and more than two thirds as much protein as all other food materials together.

In the United States, according to the last census (Census of 1910 covering the year 1909), the grains represented approximately one half (exact estimate, 48.6 per cent) of the entire value of all farm products. Much of this grain is fed to domestic animals, and the amount used as human food is not known. The amount of grain ground or milled in mills large enough to be classified as manufacturing establishments was estimated at 806,247,961 bushels and the product valued at \$883,584,405.

The grains of most importance as human food and the chief mill products of each will be considered separately in the paragraphs which follow. It may, however, be said of all these grains that they consist chiefly of starch embedded in a network of protein material and protected by a fibrous coating known as the bran. A small part of the grain consists of the germ, which is usually much less starchy and much richer in protein and fat than the body of the kernel (the endosperm). In milling the grains for human food the outer layers and the germ are usually removed to a greater or less extent, as will be shown more fully below. Only in the case of wheat shall we take space to describe the milling process.

Barley

The cultivated barleys belong to two or three different species of the genus *Hordeum*.

The barley crop of the United States in 1909 was estimated at 173,000,000 bushels, valued at \$92,459,000. It was grown principally in the states of Minnesota, North Dakota, California, South Dakota, Wisconsin, and Iowa.

The grain is about as large as wheat, one hundred kernels weighing about 4 grams. As human food it appears in this country chiefly in the form of "pearled barley," used mainly in soups, and "patent barley flour" for infant feeding. In making pearled barley the germ and most of the bran is removed without grinding the remainder of the grain. "Patent" barley flour is a finely ground product representing the grain from which the outer layers have been removed more completely than in making pearled barley, but perhaps not so completely as in making "patent" flour from wheat. The following are comparative analyses of barley (the entire kernel), pearled barley and patent barley flour (Table 27).

TABLE 27. COMPOSITION OF BARLEY AND BARLEY FLOUR

	BARLEY (ENTIRE GRAIN)	PEARLED BARLEY	"PATENT" BARLEY FLOUR
Moisture <i>Per cent</i>	11.9	11.3	10.3
Protein (nitrogen $\times 6.25$) . . . <i>Per cent</i>	10.5	8.5	8.0
Fat (ether extract) <i>Per cent</i>	2.2	1.1	1.7
Carbohydrates (by difference) <i>Per cent</i>	72.8	77.8	79.35
Fuel value, Calories per pound . . .	1610.	1615.	1650.
Weight of 100-Calorie portion,			
in grams	28.	28.	28.
in ounces	1.0	1.0	1.0
Total ash <i>Per cent</i>	2.6	1.3	0.65
Phosphorus (calc. as P_2O_5) . . . <i>Per cent</i>	0.95	0.46	0.30
Iron (calc. as Fe) <i>Per cent</i>	0.004	0.0013	0.0010

Notice in what respects the mill products differ from the original grain, and compare the corresponding data for other grain products beyond.

Osborne found in barley an alcohol soluble protein, different from that of wheat or of rye, to which he gave the name "hordein." The products of hydrolysis and the ultimate composition of hordein are given in comparison with some other grain proteins beyond. The albumin, the globulin, and the proteose extracted from barley were judged by Osborne to be probably identical with the corresponding proteins found in wheat and rye.

Barley which has begun to sprout (called malted barley or simply "malt") is rich in an enzyme which digests starch with production of maltose. Enzymes which digest starch are called *amylases*, commonly also "diastases." The characteristic enzyme of malted barley is commonly called malt diastase. On account of its high "diastatic power," due to abundance of this enzyme, barley malt is largely used in the fermentation industries as a means of digesting the starch (of the barley itself and often also of other grains) into fermentable sugar. More

of the barley grown in the United States is used for this latter purpose than for food.

Buckwheat

Buckwheat, the seed of *Fagopyrum esculentum*, is not strictly a cereal (since the plant which bears it does not belong to the true grasses) but for practical discussion is usually grouped with the cereal grains. Although more popular as a food in the United States than elsewhere, the amount grown is small as compared with other grains. The production of 1909 was estimated at 14,849,000 bushels, and valued at \$9,331,000.

The buckwheat kernel is about as large as that of wheat or barley and is characterized by its different shape and higher proportion of fiber due to its thick protective covering. The latter is rejected in milling the grain so that the "fine" buckwheat flour has like "fine" wheat flour only a negligible amount of fiber — about one half of one per cent.

Typical American analyses of buckwheat and buckwheat flour are as follows (Table 28):

TABLE 28. COMPOSITION OF BUCKWHEAT AND BUCKWHEAT FLOUR

	BUCKWHEAT (ENTIRE GRAIN)	BUCKWHEAT FLOUR
Moisture Per cent	12.3	11.9
Protein (nitrogen $\times$ 6.25) Per cent	10.7	8.7
Fat Per cent	2.0	1.6
Carbohydrates (other than fiber). . Per cent	62.8	76.2
Fiber Per cent	10.7	0.6
Ash Per cent	1.8	1.0

In order to comply with the standard of the Association of Official Agricultural Chemists, buckwheat flour must contain not more than 12 per cent moisture, not less than 1.28 per cent nitrogen, and not more than 1.75 per cent of ash.

Maize or Indian Corn (*Zea mays*)

Maize or Indian corn (commonly called "corn" in the United States, though the word corn in English literature usually refers to the wheat plant) is a native American plant and has long been (economically) the most important single crop raised in the United States. The area annually planted to maize in this country is said to be nearly equal to the entire area of France or Germany. A normal crop is estimated by the United States Department of Agriculture at 3,000,000,000 bushels and valued at something over \$1,500,000,000. The Census returns for 1909 showed 2,552,000,000 bushels valued at \$1,439,000,000. According to Census reports, corn occupied, in 1909, 20.6 per cent of the improved farm land of the country and contributed 26.2 per cent of the total value of crops. In Illinois and Iowa about one third of the improved farm land is occupied by corn, and in Kansas, Nebraska, and Missouri over one fourth. The relative distribution of corn culture throughout the United States is shown in Fig. 10 (Chapter VI).

Of the total corn crop from 85 to 90 per cent is fed on farms and only 10 to 15 per cent comes to market. According to Census returns for 1909 only 209,281,237 bushels of corn were ground in mills large enough to be classed as manufacturing establishments. In addition to this, however, 2,240,508,915 pounds (about 40,000,000 bushels) of corn were recorded as used for the manufacture of cornstarch and glucose.

From the corn ground in the mills covered by the Census returns there were produced 21,552,737 barrels of corn meal and corn flour valued at \$66,941,095.

It will be seen that in the corn crop there is an enormous reserve supply of material suitable for human food. To any extent that the demand for corn meal makes it more profitable for the farmer to sell his corn to the miller than to use it in raising and fattening farm animals, the supply of corn meal can be

increased up to about ten times the amount now milled without necessarily increasing the amount of land devoted to corn raising. To use for human food a large proportion of the corn now fed to farm animals, would of course diminish somewhat the amount of meat produced, but as was pointed out in Chapter V, one can never recover in the edible flesh of the carcass more than a small fraction of the protein and energy which was required for the growth and fattening of the animal.

The following approximate analyses (Table 29) indicate the more significant differences in composition between (1) the kernel as a whole, (2) the "old process" corn meal made by grinding the entire kernel and sifting out only the larger particles of bran, (3) the "new process" corn meal in the making of which the bran is more completely removed and the germ is also rejected.

TABLE 29. ANALYSES OF CORN AND CORN MEAL

	CORN (ENTIRE KERNEL)	OLD PROCESS CORN MEAL	NEW PROCESS CORN MEAL
Moisture <i>Per cent</i>	10.7	11.6	12.0
Protein (nitrogen $\times 6.25$) . . <i>Per cent</i>	10.0	9.0	7.8
Fat <i>Per cent</i>	4.3	4.3	1.3
Carbohydrate (other than fiber) <i>Per cent</i>	71.8	72.5	78.5
Fiber <i>Per cent</i>	1.7	1.5	0.8
Ash <i>Per cent</i>	1.5	1.3	0.6
Phosphorus (calc. as P_2O_5) . <i>Per cent</i>	0.7	0.7	0.22

To meet the requirements of the standards proposed by the Association of Official Agricultural Chemists, corn meal must contain not more than 14 per cent of moisture, not less than 1.12 per cent of nitrogen, and not more than 1.6 per cent of ash.

The establishment of official grades and standards for corn itself is now under consideration in the United States Department of Agriculture.

The composition of the corn kernel can be altered by breeding and selection. Hopkins and Smith of Illinois Agricultural Experiment Station starting with corn containing 10.92 per cent protein and 4.70 per cent fat have by breeding and selection through ten years (ten generations of the corn plant) produced a "high protein" strain with 14.26 per cent protein and a "low protein" strain with 8.64 per cent of protein; also a "high fat" strain with 7.37 per cent, and a "low fat" strain with 2.66 per cent of fat.

Osborne finds that corn contains an albumin, at least three globulins, a proteose similar to that in wheat, an alcohol-soluble protein (different from those of other grains) to which the name zein has been given, and an insoluble glutelin. The zein and glutelin are included in the discussion of chemical structure and food value of grain proteins beyond.

A maize kernel of the varieties chiefly cultivated in the United States has about ten times the weight of a kernel of wheat. Like the latter it has a fibrous outer skin beneath which is a layer rich in protein and phosphorus compounds which is often called the gluten layer; within these outer layers lie the germ, constituting about one tenth, and the endosperm, which makes up between eight tenths and nine tenths of the entire kernel.

TABLE 30. COMPOSITION OF CORN KERNEL AND ITS PARTS (WAGNER)

PART	PROPOR- TION OF THE WHOLE	PROTEIN	FAT	CARBO- HYDRATE OTHER THAN- FIBER	FIBER	ASH
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Original kernel	100.0	12.6	4.3	79.4	2.0	1.7
Skin	5.5	6.6	1.6	74.1	16.4	1.3
Germ. . . .	10.2	21.7	29.6	34.7	2.9	11.1
Endosperm .	84.3	12.2	1.5	85.0	0.6	0.7

The bran obtained in the ordinary grinding of corn includes along with the fibrous hull a considerable proportion of the so-called gluten layer. When the corn kernel is soaked to loosen the skin, the latter may be removed alone, leaving the starchy and the "glutenous" parts of the endosperm together. Wagner gives the above analyses of the skin, the germ, and the endosperm as thus separated (Table 30).

We have spoken of the hull as fibrous covering, yet the above analysis indicates that the fiber constitutes only about one fifth of the total carbohydrate of the hull. This is partly because only the fiber sufficiently resistant to remain after successive boiling with acid and alkali is reported as "fiber" in the analysis, while all the material (other than protein, fat, and ash) which is dissolved by the acid or the alkali is reported as "carbohydrate other than fiber" or as "nitrogen-free extract." The latter therefore includes not only the starch, but also the pentosans and much of the so-called lignin or lignone substances, which in their chemical nature are not strictly carbohydrate but which are usually grouped with the carbohydrates because of their close association with cellulose. The material designated in the table as carbohydrate other than fiber is therefore quite different for different parts of the kernel: in the hull it is chiefly pentosan; in the endosperm, chiefly starch; in the germ there is much less starch and an appreciable amount of sugar.

The chief differences in composition among the different parts of the corn kernel may be summarized as follows: The hulls contain much fiber and wood gum (pentosans) and relatively little starch, protein, or fat; the endosperm is rich in starch, low in fiber, relatively poor in fat and ash, and has about the same percentage of protein as the entire kernel; the germ contains little starch, but is rich in fat, protein, and ash. The fat is liquid at ordinary temperatures and therefore usually referred to as oil. It is classed as a "semi-drying" oil, being intermediate

in properties between olive oil and linseed oil. The chemical nature and nutritive value of the proteins and ash constituents will be discussed along with those of wheat farther on in this chapter.

The industrial process of separating and refining the chief components of corn will now be described in brief outline.

Of an average corn crop of about 3,000,000,000 bushels it is estimated that about nine tenths will be used on the farms and about one tenth or 300,000,000 bushels will be sold. The corn sold is sometimes referred to as "cash corn." Of all the corn which leaves the farm, the milling and fermentation industries together take about five sixths, and, nearly one sixth, or 40,000,000 to 50,000,000 bushels per year, is used for the manufacture of corn starch, corn sirup, etc., as described below.

Manufacture of Starch and Other Products from Corn

The corn is first cleaned and sent to steeping tanks, where it is soaked (steeped) for about 2 days in warm water to which has been added a small amount of sulphurous acid to prevent putrefaction and assist in the loosening of the hull.

This steeping causes the corn to swell, and brings about a softening of the endosperm which facilitates the subsequent separation of the germ.

The steeped grain is then coarsely ground in mills so arranged as to disintegrate the kernel without breaking the germ. The type known as the Foos or Fuss mill, in which the grain is torn to pieces by passing between parallel studded plates which revolve in opposite directions, is generally used.

The ground mass is then run into the "separators," which are long tanks or vats containing a mixture of starch and water of a density of 8° Baumé (1.06 specific gravity). The germs, on account of the oil which they contain, float on this liquid, while the hulls and starch granules tend to settle to the bottom. The

separation is a continuous process, the ground mass being introduced at one end of the tank while at the other end the germs float off at the top and the other constituents are drawn off from the bottom.

The germs are repeatedly washed with water to remove any adhering starch, then dried in revolving steam dryers and the oil extracted by pressure. At present the oil is employed to only a small extent for food, the greater part being used in making soaps and soap powders, in the tanning industry, in paint and putty, and in the manufacture of rubber substitutes and water-proofing and insulating materials. Oil cake, as the mass remaining after pressing the dried germs for oil is called, contains still a considerable amount of fat and is very rich in protein. At present most of this oil cake is exported to Europe, where it is used in stock-feeding, perhaps after removal of a further portion of oil. In view of the high food value of the germ and the fact that it constitutes about one tenth of the entire grain, it seems unfortunate that it enters so little into human consumption.

The coarsely ground mass drawn off from the bottoms of the separator tanks as described above, and which represents all of the corn except the germ and the water-soluble substances, is reground in burr-stone mills ("Buhr" mills) and the semi-liquid mass passed over "shakers." These are mechanically shaken sieves of bolting cloth of about 200 mesh which sift out the particles of hull while the starch granules and most of the protein pass through. The hulls are sprayed with water while on the sieves and are usually reground and the process repeated two or three times to complete the removal of the starch from the particles of hull. The final disposition of the hull is described in the paragraph on by-products below.

The liquid which has passed through the "shakers," and which contains practically all of the starch and most of the protein of the corn, is known as the raw starch liquor. This is adjusted to density of 4° to 5° Baumé (1.03 to 1.045 specific

gravity) and then passed into very long flat-bottomed tanks known as "runs" or "tables." These are almost level, being usually 100 to 120 feet long and inclined only about 4 inches. As the raw starch liquor flows slowly down the run, the starch granules settle out gradually and in rolling along the bottom before finally coming to rest they tend to rub each other free from adherent protein. The length and inclination of the "runs" and the concentration of the raw starch liquor are so adjusted that nearly all of the starch settles before reaching the lower end of the run, while most of the protein remains suspended in the water which flows out and which is known as the "gluten liquor." The solids of this "gluten liquor" are recovered in the gluten feed described in the paragraph on by-products below.

When the "gluten liquor" has been drained off from the "run" the starch which has settled is found in a very compact deposit which may be dug out in blocks like stiff wet clay. As taken from the "tables" or "runs" it is known as "green starch." This may be utilized directly for the manufacture of glucose or corn sirup. To refine the "green starch" for eating or for industrial use it is stirred with water and again sent over the "run," or washed more quickly by decantation, according to the degree to which the starch is to be freed from protein; or in preparation for certain purposes it may be washed with dilute alkali. The latter is more effective in removing the protein than is water alone, but the subsequent removal of the alkali from the starch is difficult. Being used for many industrial purposes as well as for food, starch and dextrin are prepared in a variety of forms the description of which does not come within the scope of this book.

For the manufacture of commercial glucose, the "green starch" is stirred with water to make a suspension of a density of about 20° to 22° Baumé (1.16 to 1.18 specific gravity), to which is added hydrochloric acid in such proportion as to make

about 0.1 per cent of actual acid in the entire mixture. This mixture is treated with superheated steam in strong metal cylinders called converters. The converters now in use are six feet in diameter and may be as much as twenty feet high. By running in superheated steam up to a pressure of 35 pounds per square inch, the hydrolysis of the starch is greatly accelerated and is brought to the desired point in a few minutes. The pressure is then released and the acid neutralized with sodium carbonate. The neutral solution is then filtered clear, concentrated by evaporation, decolorized by running through bone-black filters like those used in the refining of cane sugar (Chapter XI), and finally evaporated further to a viscous sirup containing 80 per cent or more of solids.

The average composition of this sirup according to Wagner is:

	PER CENT
Water	19.0
Glucose (Dextrose)	38.5
Dextrin	42.0
Ash	0.5

In this case it is assumed that glucose (dextrose) is the only reducing sugar present. According to Rolfe and Defren, however, there would be present at the stage of hydrolysis reached in this process, a considerable amount of maltose, so that the actual percentage of glucose would be less than that given by Wagner. In any case it will be seen that considerably less than half of the carbohydrate material is actually in the form of glucose. This product is called "commercial glucose" or "corn sirup"; to call it simply glucose is obviously inaccurate and contrary to the regulation that a food product which is a mixture must not be sold under the name of a single constituent.

The manufacture of purified corn starch and of corn sirup or commercial glucose are usually carried on in the same factories. Both industries have developed rapidly in recent years. According to the Census report there were produced in the United

States, in 1909: 638,825,366 pounds of corn starch valued at \$15,962,916; 769,660,210 pounds of commercial glucose sirups valued at \$17,922,514; 159,060,478 pounds of solid glucose valued at \$3,620,816; 8,164,175 gallons of corn oil valued at \$2,802,768; \$6,013,968 worth of stock food and \$924,422 worth of miscellaneous by-products of this industry.

The characteristics and uses of commercial glucose sirup will be considered further in Chapter XI.

By-products. In addition to the starches, sirups, and glucose sugars which may be considered the direct products of this industry, we have already discussed the utilization of the corn oil and the oil cake or germ meal. The washed hulls, the "gluten liquor," and the soluble substances extracted when the corn was steeped in warm water at the beginning of the process remain to be considered.

While giving the composition of the isolated skin of the corn kernel as in Table 30 above Wagner states that the corn hulls obtained in the process just described contain when dry as much as 14 per cent protein and may therefore be considered as a cattle food of considerable value. The custom, however, is not to market the hulls alone, but to mix them with the protein obtained from the liquor which has passed over the runs.

When the solids of the "gluten liquor" are dried alone, there is obtained a "gluten meal" which averages over 40 per cent of protein. Usually, however, the gluten meal, the hulls, and the concentrated steep-water are dried together.

The steep-water contains the greater part of all the constituents of the corn which are readily soluble in slightly acidulated water, such as the ready-formed sugars of the kernel, some of the proteins, the "nitrogenous extractives," much of the organic phosphorus compounds such as phytin, and the greater part of the ash constituents. The following partial analysis of the solids of the steep-water (also called "corn solubles") is given by Wagner:

	PER CENT
Nitrogenous substances	38-43
Reducing sugars as dextrose	25-30
Phosphorus (calc. as P_2O_5)	6-8
Potash (K_2O)	5-6
Magnesia (MgO)	2-3

The general similarity of this material to meat extract and yeast extracts suggests that it may have an interesting future in the food industries. At present the steep-water is concentrated, mixed with the wet hulls and the solids of the "gluten liquor," and the whole dried, ground, and sold as "gluten feed." The average composition of this gluten feed is given by Wagner as follows:

	PER CENT
Moisture	10.36
Protein	25.95
Fat	2.18
Starch	18.09
Fiber	6.50
Other carbohydrates	33.22
Ash	3.70

The more efficient the factory the higher is the percentage of protein and the lower the percentage of starch and *vice versa*.

Oats

Oats belong to different species of the genus *Avena*, the kind commonly cultivated being *Avena sativa*. Oats culture is widely distributed over Europe and America, and the grain very generally used both as human food and for feeding farm animals.

According to census reports the oat crop of the United States in 1909 was 1,007,000,000 bushels valued at \$415,000,000. Of the total oat crop about one twentieth (50,241,598 bushels) was reported among the materials used by the milling industry, and an unknown amount was used in the manufacture of specially prepared "breakfast foods."

The husk of the oat adheres closely to the grain and is not

usually removed before sending the grain to market. The following analyses of oats with and without the husks and of oatmeal as ordinarily ground are from bulletins of the United States Department of Agriculture.

TABLE 31. ANALYSES OF OATS AND OAT PRODUCTS

	OATS, EN- TIRE KER- NEL WITH HUSK	OAT KERNEL WITHOUT HUSK	OATMEAL	ROLLED OATS
Moisture <i>Per cent</i>	10.06	6.93	7.3	7.7
Protein <i>Per cent</i>	12.15	14.31	16.1	16.7
Fat <i>Per cent</i>	4.33	8.14	7.2	7.3
Fiber <i>Per cent</i>	12.07	1.38	0.9	1.3
Carbohydrates, other than fiber <i>Per cent</i>	57.93	67.09	67.5	66.2
Ash <i>Per cent</i>	3.46	2.15	1.9	2.1

It is evident from these averages that in general oatmeal and rolled oats have about the same composition and represent nearly the whole of the oat kernel. In the making of these products the chaffy husk is of course eliminated and with it is usually removed a portion of the skin of the kernel, and sometimes the tips of the kernels are also scoured off, but the greater part of the germ and a considerable part of the outer layers of the kernel remain in the product offered for sale. Oatmeal and rolled oats are therefore relatively rich in fat as well as in protein, and are somewhat more concentrated foods, both from the standpoint of energy value and protein content, than are the other staple grain products.

The proteins of oats have proven particularly difficult to purify and have therefore not yet been studied so thoroughly as have some of the other grain proteins.

Farther on in this chapter the nutritive value of oat products and their place in the diet will be considered in connection with the same characteristics of other grain products.

Rice (*Oryza sativa*)

If the population of the entire globe be considered, rice is probably the most used as human food of all the grains, since it enters so largely into the dietary of the people of India, China, and Japan.

In the United States rice plays the part only of a minor cereal, but its cultivation is increasing, especially in Louisiana and Texas. Smaller areas are devoted to rice culture in the South Atlantic States. The production of rough rice (rice before milling or polishing) in the United States in 1909 was estimated at 21,839,000 bushels, and the value at \$16,020,000.

Rice has been commonly marketed in this country either, (1) unhulled, *i.e.* with the chaffy husk still covering the kernel; (2) "cured," freed from husk but not from bran; (3) polished (white). The following comparative analyses (Table 32) of rice in these three conditions are from Bulletin 13, Bureau of Chemistry, United States Department of Agriculture, except the figures for phosphorus, which have been added by the author.

TABLE 32. ANALYSES OF RICE

	UNHULLED RICE	"CURED" RICE	POLISHED RICE
Weight of 100 kernels Grams	2.929	2.466	2.132
Moisture Per cent	10.28	11.88	12.34
Protein Per cent	7.95	8.02	7.18
Fat Per cent	1.65	1.96	0.26
Fiber Per cent	10.42	0.93	0.40
Carbohydrates other than fiber . Per cent	65.60	76.05	79.36
Ash Per cent	4.09	1.15	0.46
Phosphorus calc. as P ₂ O ₅ . . . Per cent		0.65	0.20

It will be seen that the "polishing" of the rice kernel removes only about one eighth of its weight but more than half of its ash constituents. The ash in both cases is composed chiefly

of phosphates, about one half of the weight of ash being P_2O_5 . It has been known for some time, especially in Japan and the Philippines, that a diet consisting chiefly of polished rice is likely to result in the disease *beriberi*, and by careful observation and experiment it was decided that rice which had been polished so as to contain less than 0.40 per cent of P_2O_5 was unsafe for use as the chief article of food, as rice often is used in those countries. The frequency with which beriberi follows a deficient diet, such as one consisting mainly of highly polished rice, and the certainty with which it can be prevented by simply substituting unpolished (also called "cured") rice, shows plainly that the removal of the outer portions of the rice kernel as in the "polishing" process results in a deficiency of some substance or substances which occur in that part of the grain and which are important for the maintenance of health. Beriberi is therefore considered typical of the "deficiency diseases." The limit to which rice may be "refined" without becoming markedly deficient has been determined in terms of its phosphorus content, and it is altogether probable that a diet of polished rice taken in sufficient quantity to furnish all the energy required in nutrition would fail to furnish an adequate supply of phosphorus. Recent experiments indicate, however, that so far as beriberi is concerned, the deficiency of the polished rice is due more particularly to the removal of certain non-protein nitrogen compounds to which the general term "vitamines" has been given. Those who desire to study this subject further may be referred to Vedder's book *Beriberi* (New York, 1913) and to the journal literature cited in the references given at the end of this chapter.

Partly as a result of the interest aroused by the rather striking demonstration in the Philippines of the impoverishment of rice by the complete removal of the outer layers to make a white product, "cured" or "brown" rice is now being introduced in the grocery trade.

Rye (*Secale cereale*)

Rye is said to be the hardiest of the cereals and in parts of Europe is more commonly used as a bread-making material than wheat. The United States produces less than one twentieth as much rye as wheat, the rye crop for 1909 being 29,520,000 bushels valued at \$20,422,000. The census of manufactures for the same year shows 11,503,969 bushels of rye used and 1,532,139 barrels of rye flour produced by the flour and grist mills large enough to be listed as manufacturing establishments. The mean composition of 20 samples of rye (18 of which were grown in the United States) analyzed at the World's Fair at Chicago in 1893 was as follows:

Weight of 100 kernels	Grams	2.516
Moisture	Per cent	10.77
Protein	Per cent	12.26
Fat	Per cent	1.58
Fiber	Per cent	2.08
Carbohydrates, other than fiber	Per cent	71.42
Ash	Per cent	1.92

In bread-making qualities rye approaches wheat more nearly than does any other grain.

Osborne has investigated the proteins of rye and reports that they are similar to, but not identical with, those of wheat. The presence of a large amount of gummy carbohydrate in rye makes the separation and purification of the rye proteins unusually difficult. Only the alcohol-soluble protein (prolamin) of the rye has been obtained satisfactorily purified in sufficient quantity for examination by modern methods. The products of its hydrolysis are shown in comparison with those of wheat and maize proteins beyond.

Wheat

Wheat is the typical bread-making grain and the one most used for human food in the United States, in English-speaking countries generally, and in probably the greater part of Europe.

The different cultivated varieties of wheat all belong to the same genus (*Triticum*), but not all to one species. The wheat most commonly grown in America is *Triticum vulgare*, and probably the next most important from our standpoint is *Triticum durum*, which is valuable because of its ability to resist drouth and also because of yielding a flour suited to the manufacture of macaroni. Wheat is often classified as "hard" or "soft," as "spring" or "winter" wheat, and also according to the locality in which it is grown.

Winter wheat is sown in the autumn in regions where the winter is not severe, and matures early in the summer. Spring wheat, which is grown mainly in the Northwestern states, including Minnesota and the Dakotas, and in Canada, is sown in the spring and matures in the late summer. There are many varieties of both classes, and the composition and properties vary with variety and environment. As a rule, winter wheats are softer and somewhat more starchy; the spring wheats harder and slightly richer in protein. In general a rather hard wheat of more than average protein content is preferred for the manufacture of bread flour, but the wheats with most protein do not necessarily make the best flour, since the bread-making quality depends upon the nature and quantitative relationship of the proteins and not simply on the amount present.

In bulk and value of crop, wheat ranks second to corn in production in the United States, but in quantity sold from the farms and sent into commerce it ranks first among the grains. The last United States Census shows a production in 1909 of 683,000,000 bushels valued at \$658,000,000.

The states contributing most largely to this total were North Dakota, Kansas, Minnesota, and South Dakota, these four states having over two fifths of the wheat acreage of the United States.

The Census returns for exports of wheat and flour for the year corresponding to the crop of 1909 show the equivalent of 87,364,-

ooo bushels of wheat, or practically one eighth of the amount raised. The amount consumed in the United States may therefore be estimated at about 6.5 bushels per person per year. Apparently the per capita consumption of wheat is nearly the same in America and in England, Hutchison's estimate from English data being 6 bushels.

Census returns show 496,480,314 bushels of wheat ground in 1909 in flour and grist mills in the United States large enough to be classed as manufacturing establishments. The corresponding production of flour was 105,756,645 barrels valued at \$550,116,254.

The structure of the wheat kernel is doubtless already familiar to most readers of this book. We shall therefore not repeat the

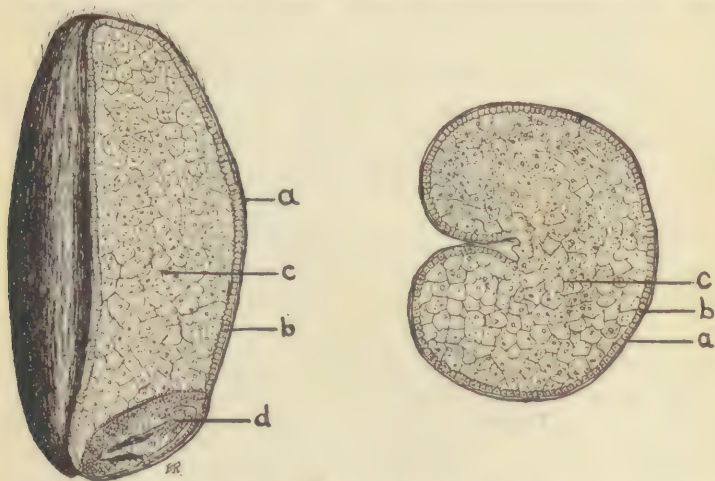


FIG. 20. — Diagram of grain of wheat, longitudinal and transverse sections. *a*, bran; *b*, aleurone layer; *c*, starch cells of endosperm; *d*, germ.

description here, and it must be understood that this paragraph is not intended as an adequate description but only as a reminder of a few of the points which are to be kept in mind when con-

sidering the production and composition of the mill products. It should also be clearly understood that Fig. 20, representing some features in the structure of the wheat kernel, is only a diagram to illustrate these few points and is not intended as a complete picture. The bran, which is actually composed of several layers, is shown at *a*. The square cells of the aleurone layer are shown at *b*, while *c* represents the endosperm made up chiefly of "starch cells" which, however, always contain protein as well as starch. The germ or embryo, *d*, is shown at one end of the longitudinal section, but does not appear in the transverse section, since the germ does not extend to the middle of the kernel. The deep crease extending from end to end of the wheat kernel increases the surface considerably so that the percentage of bran and of aleurone layer is larger than would otherwise be the case. It is estimated that the bran proper (including epidermis, epicarp, endocarp, and testa) constitutes about 5 per cent, the aleurone layer about 8 per cent, the germ with its membrane about 5 per cent, and the "starch cells" about 82 per cent of the entire grain. The "bran" obtained in milling may contain not only the bran proper, but also the germ and more or less of the aleurone layer, depending upon the processes employed. The flour obtained in ordinary milling contains more or less of the aleurone layer, which is rich in protein and in phosphorus compounds, and most of the "starch cells" of the original kernel. From the relative proportions in which these exist in the grain it is evident that much the larger part of ordinary white flour must consist of these starch cells, and their general nature should therefore be kept in mind. Each cell contains hundreds of starch granules of various sizes embedded in a network of protoplasmic material composed essentially of protein matter, in this case chiefly gliadin and glutenin, the proteins which together form the characteristic gluten of wheat flour. The accompanying diagrams (Fig. 21) published by the United States Department of Agriculture illustrate respectively the proto-

plasmic structure or protein components of the cell and the starch granules which are found deposited in it. A view through *both* of these diagrams would represent the structure and composition of the "starch cell" as a whole. It should be clear that even the whitest and most starchy part of the wheat kernel contains a significant amount of protein.

The granules of wheat starch vary greatly in size—in fact, this is one of the properties by which wheat flour is identified

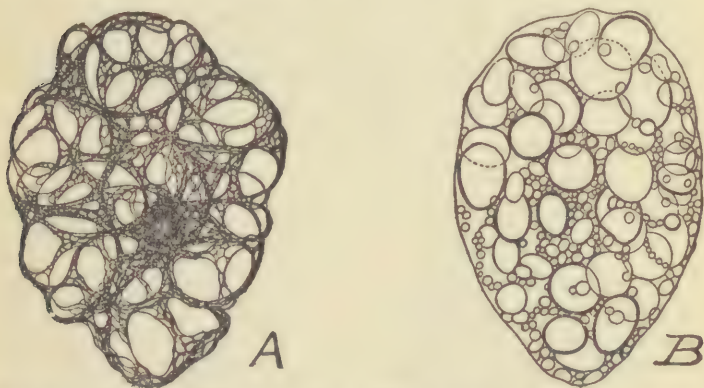


FIG. 21.—Diagram of "starch cells" or "flour cells" of wheat. *A*, showing network of protein; *B*, showing starch granules.

under the microscope. That the average size is quite small may be appreciated from the fact that a kernel of wheat weighing less than 0.04 gram is estimated to contain from 10,000,000 to 20,000,000 starch granules.

The wheat proteins have been extensively investigated, especially by Osborne.¹ Gliadin and glutenin together form wheat gluten and constitute about nine tenths of the protein matter of the grain. In the whole kernel these two proteins

¹ Osborne, *The Proteins of the Wheat Kernel*. Publication No. 84, Carnegie Institution of Washington.

are present in about equal proportions, but in wheat flour there is more gliadin than glutenin. Gliadin is the best known of the alcohol-soluble proteins, and glutenin of the glutelins. In a general way it may be said that gliadin gives tenacity and elasticity to the gluten, while glutenin gives it strength, and that the two proteins must be present in proper proportions if the gluten is to have the properties desired in bread making.

In addition to the two principal proteins, Osborne finds in wheat: an albumin, leucosin; a globulin, edestin; and a proteose.

The ultimate composition of the ash-free proteins is given by Osborne¹ as follows:

TABLE 33. ULTIMATE COMPOSITION OF WHEAT PROTEINS (OSBORNE)

	APPROXIMATE AMOUNT IN WHEAT KERNEL	CARBON	HYDRO- GEN	NITRO- GEN	SULPHUR	OXYGEN
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Gliadin .	4.5	52.72	6.86	17.66	1.03	21.73
Glutenin .	4.0	52.34	6.83	17.49	1.08	22.26
Globulin .	0.6	51.03	6.85	18.39	0.69	23.04
Leucosin .	0.4	53.02	6.84	16.80	1.28	22.06
Proteose— <i>a</i> .	0.2	49.94	6.80	17.08	1.24	24.94
Proteose— <i>b</i> .	0.2	48.99	6.85	16.89	1.10	26.17

The proteose (which like the albumin and the globulin is chiefly found in the germ) appeared to be a mixture of two substances, *a* and *b*, the first of which was precipitated when its solution was saturated with sodium chloride while the second was not.

It will be seen that all of the wheat proteins contain more than 16 per cent of nitrogen, so that if the percentage of nitrogen in wheat products is multiplied by 6.25, a result higher than the actual amount of protein is obtained. As a whole the wheat proteins contain about 17.55 per cent of nitrogen so that the factor for converting nitrogen to proteins should be about 5.7 if the true weight of proteins and of carbohydrates by difference is sought, and this factor as well as the factor 6.25 is frequently used. For most of the purposes

¹ Osborne has also investigated the amino acids obtained by hydrolysis of gliadin, glutenin, and leucosin with the results shown in comparison with other grain proteins beyond.

of food chemistry and nutrition, however, the term "protein" as used in proximate analyses and dietary calculations is understood to mean the product obtained by multiplying the weight or percentage of nitrogen by the factor 6.25, which should therefore be uniformly used in such cases.

Flour and Bread

The making of flour has gradually developed from crushing the grain by hand between two stones to the highly elaborate mechanical processes now in use in the large milling centers where a single mill often requires acres of floor space and an enormous investment in machinery.

For a long period wheat was ground between millstones and the product sifted. The coarser material was sold as bran, the white material which passed the finer bolting cloth was "flour," and the material of intermediate size and color containing many small particles of bran was called "middlings."

That process has now been almost entirely replaced by the roller process, in which the wheat instead of being ground between stones is crushed between steel rolls. This process gives a somewhat more complete separation of the starchy endosperm from the bran and so yields a somewhat larger proportion of white flour than did the older process. In the roller process as now commonly carried out, about 75 per cent of the weight of cleaned wheat is obtained as white flour and the remainder is sold chiefly for stockfeeding under such names as "wheat offals," "bran," and "shorts." Under this process the term "middlings" is applied to the material yielded by that part of the endosperm which is relatively rich in protein and therefore not so quickly nor so finely pulverized as the more starchy portion but which is only yellowish, not brown in color, and quite distinct from the bran. Thus "middlings," as the term is now used, is considered by the miller a desirable constituent of flour, since it does not materially affect the color and, on account of its high gluten content, it enhances the bread-making quality.

It seems unnecessary to take space here for more than a brief outline of the roller process, especially since detailed and illustrated descriptions are so readily obtainable from some of the large millers.

Wheat which has been screened and cleaned is first passed between a pair of corrugated rollers, known as the "first break," where the kernel is flattened and somewhat crushed and a small amount of flour known as the "break" or "first break" flour is separated by means of sieves while the main portion is conveyed to the "second break" where the kernels are more completely flattened and granular flour particles are partially separated from the bran. The material passes over several pairs of rolls or breaks, each succeeding pair being set a little nearer together. This is called the "gradual reduction process," and effects a more complete separation of the flour and bran than was possible in the older processes in which the wheat was ground fine in one operation. The effect of passing through these rollers is to pulverize the inner floury part of the wheat grain, to flatten the bran (and germ), and to break up the intermediate portion into what is called "middlings." The flour is obtained by sifting, the bran and dust are separated from the middlings by means of coarser sieves, aspirators, and other devices, and the purified middlings are then passed between smooth rolls, where they are reduced to the desired degree of fineness, or, as it is sometimes expressed, where the granulation is completed.

The best grades of patent flour are not made entirely smooth and homogeneous, but are rather made to have a characteristic feel, which is due to the granulated middlings which these flours contain. A flour which has no granular feeling is not usually considered of the highest grade, but is generally rated as a soft wheat flour of poorer gluten. On the other hand, the flour should not be too coarsely granulated, and the miller in order to obtain the desired product must be careful in blending the

powdered flour obtained from earlier breaks with the granular flour obtained from the middlings.

The flour from the middlings finally passes through silk bolting cloths of 100 mesh or finer, the dust and particles of *débris* having been removed at various points in the milling process.

In some large mills in order to secure a better granulation and more complete removal of the offals the grain passes through so many rollers and sieves that 40 or more different streams of flour are obtained from the same lot of wheat. Many of these streams are then usually brought together to produce the finished flour of the ordinary commercial grades. The break flours are those obtained from the earlier crushings of the wheat and consist mainly of the innermost powdery portion of the grain, while the patent flours contain more of the harder portion known as the middlings, but no absolute definition of the term "patent flour" can be given because of differences in usage in different parts of the country. Generally the first and second patent flours are spoken of as "high grade," which term may also include what is called "standard patent flour" or "straight grade flour"; or the "straight grade" may be divided between the high grade and low grade classes. To the low grade flour belong what are called the "second clear" and the "red dog." About 72 per cent of the clean wheat is recovered in the higher grades of flour and about 2 or 3 per cent as merchantable white flour of lower grade. The higher grades are characterized by a lighter color, more elastic gluten, better granulation, and a smaller number of *débris* particles. The low grade flours contain a somewhat higher percentage of protein but are not as valuable for bread-making purposes because the gluten is less elastic.

Technical terms of the flour trade are sometimes confusing. Thus "95 per cent patent," means that 95 per cent of the total flour (not of total grain) is included in the patent, while an "85 per cent patent" is a higher grade of flour which constitutes only 85 per cent of the total flour obtained in the given process.

The composition of the mill products of wheat may vary both with the wheat and with the details of the process. The following analyses (Table 34) are for products all milled by the modern roller process from the same lot of Minnesota hard spring wheat and are therefore strictly comparable with each other. The differences of composition are therefore properly attributable to the separations effected by the milling process alone.

TABLE 34. ANALYSIS OF WHEAT AND THE PRODUCTS OF ROLLER MILLING (*United States Department of Agriculture*)

MILLING PRODUCT	WATER	PROTEIN (N $\times$ 5.7)	FAT	CAR- BOHY- DRATES	ASH
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
First patent flour	10.55	11.08	1.15	76.85	0.37
Second patent flour	10.49	11.14	1.20	76.75	.42
First clear grade flour	10.13	13.74	2.20	73.13	.80
Straight or standard patent flour	10.54	11.99	1.61	75.36	.50
Second clear grade flour	10.08	15.03	3.77	69.37	1.75
"Red dog" flour	9.17	18.98	7.00	61.37	3.48
Shorts	8.73	14.87	6.37	65.47	4.56
Bran	9.99	14.02	4.39	65.54	6.06
Entire wheat flour	10.81	12.26	2.24	73.67	1.02
Graham flour	8.61	12.65	2.44	74.58	1.72
Wheat ground in laboratory	8.50	12.65	2.36	74.69	1.80
Germ	8.73	27.24	11.23	48.09	4.71

These analyses show a gradual increase in the protein content¹ from first patent to red dog flour, but the "red dog" flour, while containing the most protein, is the poorest grade of flour from the standpoint of the baker, and in the milling of wheat it often is allowed to remain with offals and sold for cattle food. It will also be seen that the percentage of ash is lowest in those flours which are commercially rated as of highest grade and in-

¹ Note that in the above table the percentage of protein is that of nitrogen multiplied by 5.7 for the reason explained above (page 273). Increasing the protein figures in the above table by one tenth gives essentially the results which would be obtained by the use of the more common factor 6.25.

creases as we go down the list to the lower commercial grades of flour. Patent flour rarely contains more than .55 per cent ash and usually contains less than .5 per cent.

Snyder points out, however, that noticeable variations occur in the amount of mineral matter or ash in different wheats. It may also be pointed out that the ash constituents of wheat are many of them of distinct nutritive value, so that it is only from a commercial and not from a nutritive standpoint that we would classify a flour as low grade because it has a relatively high ash content.

Another study of the mill products of wheat made by Teller at the Arkansas Experiment Station, 1894 to 1898,¹ included a milling experiment in which the principal products of a long process (7 break) roller mill were analyzed with the following results:

TABLE 35. PERCENTAGE COMPOSITION OF MILL PRODUCTS OF WHEAT (TELLER)

	PATENT FLOUR	STRAIGHT FLOUR	LOW GRADE FLOUR	SHIP STUFF	BRAN	WHOLE WHEAT	PURE GERM
Water	13.75	13.90	13.22	12.25	12.85	13.90	6.80
Ash	.33	.47	.90	3.12	5.80	2.15	4.65
Crude fiber . .	.17	.26	.74	3.55	6.14	2.17	1.60
Fat	1.05	1.25	1.70	4.80	5.20	2.15	14.38
Protein (N $\times$ 5.7) ²	9.69	10.37	12.88	10.36	15.56	12.31	30.00
Carbohydrates .	75.01	73.75	70.56	59.02	54.45	63.32	36.55
Total Nitrogen .	1.70	1.82	2.26	2.87	2.73	2.16	6.34

In this investigation Teller also determined the amount of each of four different forms of nitrogen compounds in each of the main mill products, with the results shown in Table 36.

¹ Bulletins 42 and 53, Arkansas Experiment Station (Fayetteville, Ark.).

² For explanation of this factor for estimating protein from nitrogen see page 273

It will be seen that the higher commercial grades of flour, that is, those most prized for bread making, show the largest proportion of gliadin whether this be reckoned in percentage of the gluten or of the total proteins present. The quality of making an elastic dough capable of large expansion in the bread-making process depends upon both the amount and the nature of the gluten. In order to make a large light loaf of bread, the flour should have a fairly high gluten content, and its gluten should contain a high proportion of gliadin.

TABLE 36. DISTRIBUTION OF NITROGEN IN MILL PRODUCTS (TELLER)

	DIFFERENT FORMS OF NITROGEN IN PERCENTAGE OF TOTAL				PERCENTAGE OF GLIADIN IN THE GLUTEN
	Gliadin Nitrogen	Glutenin Nitrogen	Edestin and Leucosin Nitrogen	Amid Nitrogen	
Patent flour . . .	64.2	27.7	6.4	1.7	69.9
Straight flour . .	54.0	37.4	7.0	1.6	59.1
Low grade flour . .	50.5	37.7	9.5	2.3	57.3
Ship stuff	46.2	36.6	13.0	4.2	55.8
Bran	23.5	50.0	17.8	8.5	31.9
Sifted dust . . .	11.8	61.7	11.8	14.7	16.1

Analyses of flours with reference to their bread-making value often include determination of total nitrogen and of the "*gliadin number*" which shows what percentage of the total protein is in the form of gliadin.

Absorption, expansion, and baking tests may also be required in an examination of flour as to its bread-making qualities. Directions for making such tests may be found in Leach's *Food Inspection and Analysis*.

The making of bread, always prominent among household pursuits, is now also a large commercial industry. Bread and other bakery products made in the United States in bakeries large enough to be classified as manufacturing establishments

in 1909 amounted in value according to Census reports to \$396,865,000.

In recent years much careful study has been devoted to the making and judging of bread. A description of bread-making processes would lead beyond the scope of this work, but the qualities by which the product is judged may be concisely indicated by reproducing here the following recent and authoritative score card for bread.

Revised Score Card of Miss Bevier¹

General Appearance	20
Size (5)	
Shape (5)	
Crust (10)	
Color	
Character	
Depth	
Flavor	35
Odor	
Taste	
Lightness	15
Crumb	30
Character (20)	
Coarse — fine	} Texture
Tough — tender	
Moist — dry	
Elastic or not	
Color (5)	
Grain — Distribution of gas (5)	
Total	100

Leavening agents. **Compressed yeast** is commonly used for leavening bread dough and the production of such yeast is now an important adjunct of the fermentation industry.

“Top yeast” is preferred. This is separated from the wort

¹ University of Illinois Bulletin, Vol. 10, No. 25 (March, 1913).

by skimming, washed with water, freed from impurities by washing through sieves or by settling, pressed in bags in hydraulic presses, cut into cakes, wrapped in tin foil, and kept cold until distributed for use.

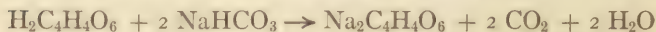
Such yeast should be used fresh, and when fresh "should have a creamy white color, uniform throughout, and should possess a fine even texture; it should be moist without being slimy. It should quickly melt in the mouth without an acid taste. Its odor is characteristic and should be somewhat suggestive of the apple. It should never be 'cheesy,' such an odor indicating incipient decomposition, as does a dark or streaked color" (Leach).

The addition of starch to yeast before pressing has been commonly practiced and justified on the ground that the starch acts as a drier, producing a yeast more easily mixed with the flour, besides making the yeast keep better, especially in warm weather. Compressed yeast has commonly contained from 5 to 50 per cent starch, although 20 per cent has been suggested (Jago) as a limit above which the starch should be considered an adulterant.

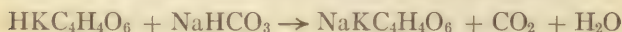
Improved methods of manufacture yield a yeast comparatively free from slime, capable of being pressed into cakes without the use of starch, and recently the Board of Food and Drug Inspection has ruled that compressed yeast should not contain starch unless so labeled.

Baking powders are used when it is desired to leaven the dough more quickly than it can be done by fermentation. Those in common use all depend upon the liberation of carbon dioxide by the action of tartaric acid or acid tartrate, acid phosphate, or alum upon sodium bicarbonate.

With *tartaric acid* the reaction is as follows:



and with *cream of tartar* (acid potassium tartrate);

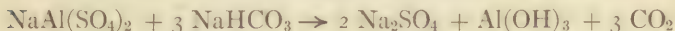


In *phosphate powders* the acid component is calcium acid phosphate and the reaction is:



The calcium acid phosphate is made by acting upon rock phosphate (tricalcium phosphate) with sulphuric acid. This reaction produces also calcium sulphate which may or may not be left in the acid phosphate when the latter is made into baking powder.

Alum powders react in the manner indicated by the following:



Formerly potassium and ammonium alums were used interchangeably according to price; now calcined sodium alum is said to be commonly used.

Mixed baking powders having more than one component which reacts with the bicarbonate are sometimes used. Thus with an alum and phosphate powder both the prompt action of the acid phosphate and the more continued evolution of gas due to the slow action of the alum may be obtained.

A moderate amount of starch or flour in baking powder is considered permissible because of its value in keeping the powder dry and thus preventing its deterioration.

Breakfast Cereals

The great variety of forms in which the grains are prepared as breakfast foods and the extravagant claims which have sometimes been made by the manufacturers have directed so much attention to these products that it is now generally understood that they resemble closely the staple grain products in composition and nutritive value. Further discussion of these products seems therefore hardly necessary here.

For detailed discussion of these products with analyses of

the different brands, the reader is referred to the following publications:

Atwater. Digestibility of Cereal Breakfast Foods. Storrs (Conn.) Agricultural Experiment Station, 16th Annual Report, pages 180-209 (1904).

Harcourt. Breakfast Foods ; Their Chemical Composition, Digestibility and Cost. Journal of the Society of Chemical Industry, Vol. 26, pages 240-243, and Ontario Department of Agriculture, Bulletin 162 (1907).

Woods and Snyder. Cereal Breakfast Foods. U. S. Department of Agriculture, Farmers' Bulletin 249.

Composition of Grain and Bakery Products

The composition of most of the grains and of several of their mill products have been given in the preceding sections of this chapter. The table which follows contains a compilation of analyses of raw and cooked grain products, taken chiefly from Atwater and Bryant and arranged according to their classification:

TABLE 37. AVERAGE COMPOSITION OF GRAIN PRODUCTS (AMERICAN ANALYSES)

DESCRIPTION	NUMBER OF ANALYSES	WATER	PROTEIN (N $\times$ 6.25)	FAT	TOTAL CARBOHY- DRATES (INCLUD- ING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
FLOUR, MEALS, ETC.								
Barley meal and flour	3	11.0	10.5	2.2	72.8	(3) 6.5	2.6	1603
Barley, pearly	3	11.5	8.5	1.1	77.8	(1) .3	1.1	1615
Buckwheat flour	17	13.6	6.4	1.2	77.9	(8) .4	.9	1577
Buckwheat preparations, self-raising	14	11.6	8.2	1.2	73.4	(1) .4	5.6	1530
Corn meal, granular	10	12.5	9.2	1.0	75.4	(1) 1.0	1.0	1620
Pop corn	2	4.3	10.7	5.0	78.7	1.4	1.3	1826

TABLE 37. AVERAGE COMPOSITION OF GRAIN PRODUCTS (AMERICAN ANALYSES) — Continued.

DESCRIPTION	NUMBER OF ANALYSES	WATER	PROTEIN (N × 0.25)	FAT	TOTAL CARBOHY- DRATES (INCLUD- ING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
FLOUR, MEALS, ETC.								
Corn preparations:								
Cerealine	5	10.3	9.6	1.1	78.3	(4) .4	.7	1640
Hominy	17	11.8	8.3	.6	70.0	(12) .9	.3	1608
Hominy, cooked	1	79.3	2.2	.2	17.8	—	.5	371
Parched	2	5.2	11.5	8.4	72.3	—	2.6	1865
Kafir corn	1	16.8	6.6	3.8	70.6	1.1	2.2	1557
Oatmeal	16	7.3	16.1	7.2	67.5	(9) .9	1.9	1811
Oatmeal, boiled	1	84.5	2.8	.5	11.5	—	.7	280
Oatmeal gruel	2	91.6	1.2	.4	6.3	—	.5	152
Oatmeal water	2	96.0	.7	1.1	2.9	—	.3	69
Rice	21	12.3	8.0	.3	70.0	(13) .2	.4	1501
Rice, boiled	3	72.5	2.8	.1	24.4	—	.2	408
Rice, flaked	2	9.5	7.0	.4	81.0	.2	.3	1647
Rye flour	8	12.9	6.8	.9	78.7	(4) .4	.7	1588
Rye meal	1	11.4	13.6	2.0	71.5	1.8	1.5	1626
Wheat flour, California fine	3	13.8	7.0	1.4	76.4	—	.5	1585
Wheat flour, entire wheat	9	11.4	13.8	1.0	71.0	(3) .9	1.0	1630
Wheat flour, Graham	13	11.3	13.3	2.2	71.4	(3) 1.9	1.8	1628
Wheat flour, prepared (self-raising)	29	10.8	10.2	1.2	73.0	(3) .4	4.8	1560
Wheat flour, patent roller process, bakers' grade	14	11.9	13.3	1.5	72.7	(6) .7	.6	1623
Wheat flour, patent roller process, family and straight grade	28	12.8	10.8	1.1	74.8	(6) .2	.5	1600
Wheat flour, patent roller process, grade not indicated	111	11.5	11.4	1.0	75.6	(16) .2	.5	1620
Wheat flour, patent roller process, high grade	57	12.4	11.2	1.0	74.9	(14) .2	.5	1603
Average of all analyses of high and medium grades and grade not indicated	210	12.0	11.4	1.0	75.1	(41) .3	.5	1610

TABLE 37. AVERAGE COMPOSITION OF GRAIN PRODUCTS (AMERICAN
• ANALYSES) — Continued

DESCRIPTION	NUMBER OF ANALYSES	WATER	PROTEIN (N × 6.25)	FAT	TOTAL CARBOHY- DRATES (INCLUD- ING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
FLOUR, MEALS, ETC.								
Wheat flour, patent roller pro- cess, low grade	13	12.0	14.0	1.9	71.2	(7) .8	.9	1625
Wheat breakfast foods: ¹								
Cracked and crushed . .	11	10.1	11.1	1.7	75.5	(7) 1.7	1.6	1635
Farina	9	10.9	11.0	1.4	76.3	(7) .4	.4	1640
Flaked	7	8.7	13.4	1.4	74.3	1.8	2.2	1648
Parched and toasted . .	6	8.6	13.6	2.4	74.5	.8	.9	1696
Shredded	6	8.1	10.5	1.4	77.9	(3) 1.7	2.1	1660
Wheat preparations:								
Macaroni	11	10.3	13.4	.9	74.1	—	1.3	1625
Noodles	2	10.7	11.7	1.0	75.6	.4	1.0	1625
Spaghetti	3	10.6	12.1	.4	76.3	(2) .4	.6	1620
Vermicelli	15	11.0	10.9	2.0	72.0	—	4.1	1587
BREAD, CRACKERS, PASTRY, ETC.								
Bread, corn (johnnycake) . .	5	38.9	7.9	4.7	46.3	—	2.2	1175
Bread, rye	21	35.7	9.0	.6	53.2	(9) .5	1.5	1153
Bread, rye and wheat . . .	1	35.3	11.9	.3	51.5	—	1.0	1163
Bread, etc., wheat:								
Buns, cinnamon, as pur- chased	1	23.6	9.4	7.2	59.1	—	.7	1537
Buns, currant, as purchased	1	27.5	6.7	7.6	57.6	1.1	.6	1488
Buns, hot cross, as purchased	1	36.7	7.9	4.8	49.7	—	.9	1242
Buns, sugar, as purchased	3	29.6	8.1	6.9	54.2	(1) .3	1.2	1413
Graham bread, as purchased	27	35.7	8.9	1.8	52.1	(11) 1.1	1.5	1189
Biscuit, homemade, as pur- chased	3	32.9	8.7	2.6	55.3	(2) .7	.5	1268

¹ The different groups of wheat breakfast foods contain various brands, which have been arranged as far as possible according to similarity in method of preparation. The varieties under each group differ only slightly from the average in percentage composition.

TABLE 37. AVERAGE COMPOSITION OF GRAIN PRODUCTS (AMERICAN ANALYSES) — Continued •

DESCRIPTION	NUMBER OF ANALYSES	WATER	PROTEIN (N × 0.25)	FAT	TOTAL CARBOHY- DRATES (INCLUD- ING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
BREAD, CRACKERS, PASTRY, ETC.								
Biscuit, Maryland, as pur- chased	2	24.6	8.4	5.6	60.1	1.3	1.3	1470
Rolls, French, as purchased	2	32.0	8.5	2.5	53.7	.6	1.3	1267
Rolls, plain, as purchased .	5	25.2	9.7	4.2	59.9	(2) .3	1.0	1435
Rolls, Vienna, as purchased	1	31.7	8.5	2.2	56.5	.4	1.1	1270
Rolls, water, as purchased	2	32.6	9.0	3.0	54.2	—	1.2	1268
Rolls, all analyses, as pur- chased	20	29.2	8.9	4.1	56.7	(12) .6	1.1	1357
Toasted bread, as purchased	5	24.0	11.5	1.6	61.2	—	1.7	1385
White bread, cheap grade .	6	33.2	10.9	1.3	53.6	—	1.0	1224
White bread, homemade .	38	35.0	9.1	1.6	53.3	(2) .2	1.0	1198
White bread, milk, as pur- chased	8	36.5	9.6	1.4	51.1	—	1.4	1160
White bread, New England, as purchased	7	36.6	9.1	1.2	52.1	—	1.0	1160
White bread, Quaker, as pur- chased	4	35.8	8.3	1.1	53.7	(3) .3	1.1	1170
White bread, Vienna, as pur- chased	25	34.2	9.4	1.2	54.1	(9) .5	1.1	1200
White bread, all analyses, as purchased, average ¹ . .	108	35.3	9.2	1.3	53.1	(27) .5	1.1	1182

¹ Analyses of similar bread made from different grades of flour, from high to low grade :

	WATER	PRO- TEIN	FAT	CAR- BOHY- DRATES	FIBER	ASH	FUEL VALUE PER POUND
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
White bread from high-grade patent flour	32.9	8.7	1.4	56.5	—	0.5	1235
White bread from regular patent flour	34.1	9.0	1.3	54.0	—	.7	1212
White bread from baker's flour . .	39.1	10.6	1.2	48.3	—	.9	1117
White bread from low-grade flour .	40.7	12.6	1.1	44.3	—	1.3	1078

TABLE 37. AVERAGE COMPOSITION OF GRAIN PRODUCTS (AMERICAN ANALYSES) — Continued

DESCRIPTION	NUMBER OF ANALYSES	WATER	PROTEIN (N × 6.25)	FAT	TOTAL CARBOHY- DRATES (INCLUD- ING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
BREAD, CRACKERS, PASTRY, ETC.								
Whole wheat bread, as pur- chased	12	38.4	9.7	.9	49.7	(1) 1.2	1.3	1113
Zwieback, as purchased . .	4	5.8	9.8	9.9	73.5	—	1.0	1915
Crackers, Boston (split) crack- ers, as purchased	2	7.5	11.0	8.5	71.1	(1) .8	1.9	1837
Butter crackers	3	7.2	9.6	10.1	71.6	(2) .4	1.5	1885
Cream crackers	9	6.8	9.7	12.1	69.7	(5) .6	1.7	1935
Egg crackers	2	5.8	12.6	14.0	66.6	.4	1.0	2008
Flatbread	3	9.8	14.9	.5	73.6	—	1.2	1625
Graham crackers	4	5.4	10.0	9.4	73.8	(2) 1.5	1.4	1904
Oatmeal crackers	2	6.3	11.8	11.1	69.0	(1) 1.9	1.8	1920
Oyster crackers	7	4.8	11.3	10.5	70.5	(1) .2	2.0	1914
Pilot bread	3	8.7	11.1	5.0	74.2	(2) .3	1.0	1752
Pretzels	2	9.6	9.7	3.9	72.8	(2) .5	4.0	1657
Saltines	2	5.6	10.6	12.7	68.5	.5	2.6	1952
Soda crackers	5	5.9	9.8	9.1	73.1	(1) .3	2.1	1875
Water crackers	6	6.4	11.7	5.0	75.7	.4	1.2	1790
All analyses	71	6.8	10.7	8.8	71.9	(45) .5	1.8	1847
Cake :								
Coffee cake	5	21.3	7.1	7.5	63.2	(4) .4	.9	1583
Cup cake	2	15.6	5.9	9.0	68.5	(1) .3	1.0	1716
Frosted cake	7	18.2	5.9	9.0	64.8	—	2.1	1650
Fruit cake	4	17.3	5.9	10.9	64.1	—	1.8	1715
Gingerbread	2	18.8	5.8	9.0	63.5	(1) .9	2.9	1625
Sponge cake	3	15.3	6.3	10.7	65.9	—	1.8	1748
All analyses, except fruit . .	27	19.0	6.3	9.0	63.3	(7) .4	1.5	1630
Cookies	20	8.1	7.0	9.7	73.7	.5	1.5	1860
Doughnuts	9	18.3	6.7	21.0	53.1	(2) .7	.9	1942
Fig biscuits or bars	1	17.9	4.6	6.6	69.8	1.7	1.1	1620
Ginger snaps	7	6.3	6.5	8.6	76.0	(5) .7	2.6	1848
Lady fingers	3	15.0	8.8	5.0	70.6	(2) .2	.6	1643
Macaroons	4	12.3	6.5	15.2	65.2	1.1	.8	1921

TABLE 37. AVERAGE COMPOSITION OF GRAIN PRODUCTS (AMERICAN ANALYSES) — Continued

DESCRIPTION	NUMBER OF ANALYSES	WATER	PROTEIN (N × 6.25)	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FULL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cals.
BREAD, CRACKERS, PASTRY, ETC.								
Pie, apple	4	42.5	3.1	9.8	42.8	—	1.8	1233
Pie, cream	3	32.0	4.4	11.4	51.2	—	1.0	1465
Pie, custard	1	62.4	4.2	6.3	26.1	—	1.0	800
Pie, lemon	1	47.4	3.6	10.1	37.4	—	1.5	1157
Pie, mince	3	41.3	5.8	12.3	38.1	—	2.5	1298
Pie, raisin	1	37.0	3.0	11.3	47.2	—	1.5	1373
Pie, squash	1	64.2	4.4	8.4	21.7	—	1.3	817
Pudding, Indian meal . . .	1	60.7	5.5	4.8	27.5	—	1.5	795
Pudding, rice custard . . .	1	59.4	4.0	4.6	31.4	—	.6	830
Pudding, tapioca	3	64.5	3.3	3.2	28.2	—	.8	702
Wafers, miscellaneous . . .	5	6.6	8.7	8.6	74.5	.4	1.6	1860
Wafers, vanilla	6	6.7	6.6	14.0	71.6	(5) .3	1.1	1990

Nutritive Value of Grain Products and their Economy as Food

The quantitative composition of the grains and of the chief food products made from them has already been given. The grains themselves, their chief mill products, and the dry cereal preparations made from them show considerable similarity in the general features of their chemical composition, and they vary but little from an average fuel value of about 1650 Calories per pound. The 100-Calorie portion of all these (dry) products is very nearly one ounce (varying only from 25 grams for oatmeal to 29 grams for rice). The cooked products naturally show greater differences, chiefly because of the presence of added water or fat.

The chemical nature and nutritive value of the carbohydrates

(chiefly starch in all of the grains) and of the fat do not offer any problem requiring further discussion.

The chemical structure of the proteins of the cereal grains has been investigated with great thoroughness by Osborne from whose results are taken the percentages of amino acids obtained on hydrolysis of these proteins as shown in Table 38.

TABLE 38. AMINO ACIDS FROM PROTEINS OF GRAIN PRODUCTS (OSBORNE)

	HON- DEIN (BARLEY)	ZEIN (CORN)	GLU- TEIN (CORN)	PRO- LAMIN (RYE)	GLIA- DIN (WHEAT)	GLU- TENIN (WHEAT)	LEU- COSIN (WHEAT)	EDES- TIN ¹ (HEMP)
Glycin . . .	0	0	0.25	0.13	0	0.89	0.94	3.80
Alanin . . .	0.43	9.79	?	1.33	2.00	4.65	4.45	3.60
Valin . . .	0.13	1.88	?		3.34	0.24	0.18	6.20
Leucin . . .	5.67	19.55	6.22	6.30	6.62	5.95	11.34	14.50
Prolin . . .	13.73	9.04	4.99	9.82	13.22	4.23	3.18	1.70
Phenylalanin . .	5.03	6.55	1.74	2.70	2.35	1.97	3.83	2.40
Aspartic acid .	?	1.71	0.63	0.25	0.58	0.91	3.35	4.50
Glutamic acid .	43.20	26.17	12.72	38.05	43.66	23.42	6.73	14.50
Serin . . .	?	1.02	?	0.06	0.13	0.74		0.33
Tyrosin . . .	1.67	3.55	3.78	1.19	1.20	4.25	3.34	2.13
Cystin . . .	1.00				0.45	0.02		1.00
Lysin . . .	0	0	2.93		0.15	1.92	2.75	1.65
Histidin . .	1.28	0.82	3.00	0.39	0.61	1.76	2.83	2.19
Arginin . . .	2.16	1.55	7.06	2.22	3.16	4.72	5.94	14.17
Ammonia . .	4.84	3.64	2.12	5.11	5.22	4.01	1.41	2.28
Tryptophan .	Present	Absent	Present	Present	Present	Present	Present	Present
Summation . .	78.17	85.27	45.44	67.55	82.69	59.68	50.32	76.95

¹ Edestin occurs also in wheat.

That glycine is absent in some cases is, as has been seen in earlier chapters, a matter of no consequence so far as food value is concerned. When, however, we find little or no lysine as in gliadin, hordein, and zein, or find tryptophan absent as in zein, we are confronted with a deficiency which we are not sure that the animal body can supply, and serious doubt is thrown upon the adequacy of such a protein as food.

Osborne and Mendel have used these proteins largely in their feeding experiments with isolated food substances and have found: (1) that when zein (lacking tryptophan) is the

only protein of the diet, it does not suffice for the needs either of a growing or a full-grown animal; (2) that when hordein or gliadin (containing tryptophan but little or no lysin) is the sole protein fed, full-grown animals can be maintained, but young animals cannot grow.

That these deficiencies in food value are actually due to the lack of the amino acids named has been shown by experiments in which the simple addition of the amino acid to the dietary was found to correct the deficiency.

This successful correlation of the chemical structure and nutritive function of the proteins is an accomplishment of the greatest importance to the scientific development of food chemistry.

It does not follow, however, from the fact that gliadin, hordein, or zein is inadequate as a sole protein food, that wheat, barley, maize, or their mill products would be correspondingly inadequate even if fed alone. Each of these grains (and of the staple mill products made from them) contains a mixture of proteins and the other proteins with which gliadin, hordein, and zein are always mixed in wheat, barley, and maize, do not show these same peculiarities of chemical structure, so that we have no reason to fear that either lysin or tryptophan would ever be wholly lacking in any staple food product made from grain. Thus glutenin, which is always present in wheat flour, has been shown to be adequate for both maintenance and growth even when it was the only protein in the diet. It is, however, only reasonable to expect that the mixture of proteins found in corn meal or even wheat flour will be of somewhat less value in nutrition than an equal weight of the mixture of proteins which we find in milk, eggs, or meat. Experimental observations confirm this inference and indicate that when bread is the sole source of protein in the diet, a larger amount of protein is required for equilibrium than when milk or meat is eaten.

Fortunately the proteins of milk (page 72) are relatively rich in those amino-acid radicles in which the grains are poor. Os-

borne and Mendel have found that their animals are not only maintained in health and vigor, but also make a normal rate of growth when three fourths of their protein is zein and one fourth is lactalbumin. If bread be made with skimmed milk instead of water, or if breakfast cereal or even corn meal mush be eaten with cream or milk, it is possible that the protein of the combination may have fully as high a value in nutrition as the average protein of ordinary mixed diet.

The digestibility of the grain proteins when fed free is probably not inferior to that of animal protein. It is evidently very largely because of the associated substances such as cell walls which still enclose the grain proteins to a certain extent in ordinary mill products, that the coefficient of digestibility of the protein of bread for example is lower than that of average mixed diet. Partly for the same and partly for other reasons, it was anticipated that the coefficient of digestibility of whole grain products might be somewhat lower than that of the finer products representing only the inner portion of the kernel.

This question was of particular interest as affecting the comparative food values of patent, "entire wheat," and Graham flours and the breads made from them. The average results of a long series of digestion experiments carried out under the auspices of the United States Department of Agriculture were as follows:

	COEFFICIENT OF DIGESTIBILITY OF	
	Protein	Carbohydrate
	<i>Per cent</i>	<i>Per cent</i>
Standard patent flour	88.6	97.7
"Entire wheat" flour	82.0	93.5
Graham flour	74.9	89.2

The lower coefficients of digestibility of the "entire wheat" and Graham flours almost exactly offset their higher protein

contents, so that it may be said that the amount of protein digested and absorbed from a pound of one of these or from a pound of patent flour is practically the same. The amount of available energy is also about the same in either case. However, as Woods and Merrill have pointed out, it does not follow that a larger amount of digestible nutrients may not be obtained from a given amount of wheat when milled as Graham flour or as entire wheat flour than when ground for patent flour, because 100 pounds of cleaned and screened wheat will yield 100 pounds of Graham flour, or about 85 pounds of "entire wheat" flour, but only about 72 pounds of patent flour. It follows that if milled on an equally large scale, *i.e.* if there were an equally large demand, Graham and "entire wheat" flours could be sold at a lower price than patent flour, but at present they usually cost as much, or in some cases even more.

Regarding the coarser and finer flours simply as sources of protein and energy, they are so nearly equal both in digestible nutrients and (at present, to the individual consumer) in pecuniary economy¹ that they may be regarded as substantially equivalent and interchangeable. They are, however, quite different in the ash constituents which they contain and somewhat different in their effect upon the digestive tract.

The coarser wheat products stimulate peristalsis more than do the fine flour products, an effect which is desirable in some persons and undesirable in others. This property of the whole wheat products is often attributed to mechanical irritation, but cannot be due entirely to this, because "bran mash" is used as a laxative with horses whose other food (hay, for example) would certainly furnish more mechanical stimulation than the bran. The wheat kernel contains two distinct substances reported as having laxative effects which are largely rejected in the preparation of fine flour. These are the oil of the germ and

¹ This, of course, does not apply to certain proprietary "whole wheat" products sold at very high prices.

the phytin (one of the phosphorus compounds) which is especially abundant in the bran. It is probable that in man the stimulation of peristalsis by whole wheat products is due in part to direct mild laxative action by one or both of these constituents, and in part also to the mechanical effect of the fibrous particles.

The ash constituents of the grains are largely concentrated in the germs and outer layers. This has been pointed out with respect to barley, maize, and rice earlier in the chapter. We shall therefore consider wheat chiefly at this point. Bran yields 10 to 20 times as much ash as patent flour. Comparing the patent flour with the whole wheat, the discrepancy is still large, the wheat containing 3 to 5 times as much of iron, of phosphorus, of calcium, or of total ash as the fine flour made from it. Thus three fourths of the ash constituents of the wheat kernel are lost to man in the process of manufacturing the wheat into white flour. Doubtless the loss in digestion is somewhat greater for the coarser than for the finer products in the case of the ash constituents as of the proteins, but there is no reason to suppose that the loss in digestion would in any case approach the loss involved in the ordinary milling process. The body probably absorbs from a pound of genuine whole wheat bread at least twice as much phosphorus, iron, and calcium compounds as from a pound of white bread. No adequate experiments upon this point appear to have been made with man,¹ but Bunge² has tested the value of the ash constituents of the bran for growing rats.

Eight young rats of the same litter and approximately the same size at the beginning of the experiment were divided into two groups of four each. One group was fed on white bread which contained 0.0015 per cent Fe, 0.045 per cent CaO, and 0.28

¹ The ordinary digestion experiments taken alone are useless if not positively misleading for this purpose because of the excretion in the feces of ash constituents which have been absorbed and utilized in the body.

² *Zeitschrift für physiologische Chemie*, Vol. 25, page 36 (1898).

per cent P_2O_5 ; the other group on whole wheat bread which contained 0.0055 per cent Fe, 0.077 per cent CaO, and 0.90 per cent P_2O_5 . The rats receiving the whole wheat bread grew much better than those fed on white bread, and were found to contain at the end of the experiment both a larger amount and a higher percentage of hæmoglobin. It was clear that the ash constituents of the outer layers of the grain were utilized for the production of bone, muscle, and blood, and that the rats receiving the whole wheat bread were much better nourished than those which were fed on white bread, though all had appeared equally well nourished at the beginning of the experiment.

In view of recent studies on rice and beriberi (page 267 and references at the end of this chapter) the probable effect upon the "vitamine" content of rejecting all but the white interior portion of the grain naturally suggests itself as a subject possibly worthy of consideration.

Some writers and teachers treat the losses incurred in the ordinary milling processes as a matter of indifference or even object to any serious discussion of the problem, calling it a "fad" on the ground that with the mixed dietary prevalent in the United States there is no danger of the "deficiency diseases" from any mode of milling the grains. This is probably true as regards the pronounced diseases such as beriberi, but it is also true that many American family dietaries show little margin of safety as regards iron, phosphorus, and calcium,¹ which makes it only reasonable that we should wish to include in the products used for human food as much as is practicable of those parts of the grain which are rich in these elements. Moreover, one should not overlook the great wastefulness of making from 100 pounds of wheat only 70 to 75 pounds of white flour when the same wheat will yield 85 to 95 pounds of flour

¹ Bulletins 185 and 227, Office of Experiment Stations, U. S. Department of Agriculture.

practically equal pound for pound if the ash constituents be ignored, and more than equal if these constituents be considered.

Pecuniary economy. The grain products, including flour, bread, corn meal, and oatmeal, constitute the most economical of the general groups of foods.

A pound of bread or 12 ounces of flour, corn meal, or oatmeal is equal in fuel value to 5 or 6 ounces of butter or fat bacon, 1 to 2 pounds steak, 2 to 3 pounds halibut or other lean fish.

In an extended series of dietary studies made at the State University of Maine, the grain products while costing only 17 per cent of the total expenditure for food furnished 40 per cent of the fuel value, 25 per cent of the protein, and 18 per cent of the phosphorus compounds.

As a rule a free use of bread and other grain products makes for both an economical and a well-balanced dietary.

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II

Barley and Malt

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CHAPTER IX

VEGETABLES, FRUITS, AND NUTS

SINCE it is difficult to draw any logical line of demarcation between vegetables, fruits, and nuts, because of the many important characteristics common to articles belonging to more than one of these categories, they will here be discussed in one chapter. The descriptive matter relating to these food materials will be taken up first; and the more critical discussion of the group as a whole, its nutritive importance and place in the diet, will follow.

Vegetables

According to Langworthy, vegetables furnish 8.7 per cent of the protein, 1.0 per cent of the fat, and 12.0 per cent of the carbohydrate of the average American dietary. The Census Reports show \$450,000,000 worth of vegetables grown in the United States in 1909. The actual value was probably greater, since this figure is based on returns which were probably not entirely complete, and on the values at the farm rather than in the market. Vegetables are therefore an important factor in the food supply and are likely to play an increasingly prominent part as their importance as food becomes better understood, and as agriculture becomes more intensified.

Of the food materials commonly known as vegetables, some are seeds, some fruits, some leaves, stems, or bulbs, and some are roots and tubers.

The plants whose *seeds* are commonly used as foods and classed as vegetables belong chiefly to the Leguminosæ, or pulse family.

Such seeds include the various kinds of beans, peas, and lentils and are known collectively as legumes or pulses. Seeds of the Graminaceæ, or grass family, which includes the common cereals, and which have been studied under the general name of "grains" in the preceding chapter, are sometimes grouped with the vegetables. Thus sweet corn is commonly classed as a vegetable, and rice, though handled as a grain crop commercially, is sometimes given the place of a vegetable on the table.

The cases in which a fleshy *fruit* enveloping the seeds is eaten as a "vegetable" rather than as "fruit" fall chiefly in the Cucurbitaceæ, or gourd family, which includes cucumbers, pumpkins, and squashes, the only exception of much importance being the tomato, which belongs to the Solanaceæ.

The plants of which the *leaves*, *stems*, *bulbs*, *roots*, or *tubers* are eaten are widely distributed through the vegetable kingdom. Thus beets, chard, and spinach belong to the Chenopodiaceæ; cabbage, to the Cruciferæ; onions and leeks, to the Liliaceæ; the potato, to the Solanaceæ; carrots, parsnips, and parsley, to the Umbelliferæ.

Since among the materials commonly called vegetables there is so little relation between the botanical position of the plant and its use as food, it seems best to follow here the common grouping of the vegetables rather than their botanical classification.

Legumes or Pulses

Beans, peas, and legumes are marketed as food both in the green condition (fresh or canned) and in the dry state, the dry legumes being sometimes classed as "grains." The Census Bureau reports the production of dry edible beans in the United States in 1909 at 11,251,000 bushels valued at \$21,771,000 and that of dry peas at 7,129,000 bushels valued at \$10,964,000.

Fresh legumes do not appear separately in the census reports. Hence we have no statistical data as to the extent to which the

green and dry legumes together enter into the food supply of the country as a whole. From the data of about 400 studies of families and other groups of people, Langworthy estimates that they supply 3.3 per cent of the protein, 0.2 per cent of the fat, and 2.0 per cent of the carbohydrate in the average American dietary.

On account of the recent growth of the pea-canning industry, it seems likely that the legumes may now be playing a larger part in the food supply than at the time of the observations upon which Langworthy's estimates are based.

The present methods of canning peas are described by Bitting in Bulletin 125 of the Bureau of Chemistry, United States Department of Agriculture, from which the following paragraphs are taken :

Pea canning is one of the most important lines of the canning industry, being third in order of output, tomatoes and corn being, respectively, first and second, although peas are second in point of value. The pea pack for 1907 is estimated at 6,505,961 cases, valued at \$14,650,000.

The first labor-saving device of importance in pea canning was the podding machine invented by Madame Faure in France in 1883. The invention was practically duplicated in this country in 1889. The American podding machine was improved, and in 1893 it was patented as a vining machine. The whole pea-canning industry was changed by this invention. Practically all of the peas canned in this country are passed through these vining machines, so that their use has virtually changed the growing of peas in small patches — market-garden fashion, with hundreds of persons going over the vines and picking the pods — to the cultivating of large fields which are cut by a machine. The viner occupies the same relation to hand picking in the pea-canning industry that the thrashing machine does to the flail in the thrashing of wheat.

The first operation through which the peas pass after leaving the viner is that of washing. This is accomplished in what is known as the squirrel cage, which is a wire cylinder about 3 feet in diameter and 12 feet long. The cylinder is set on a slight incline so that when the peas are admitted at one end they will tend to roll to the other as the cylinder revolves. On the inside is a perforated pipe that sprays a stream of water upon the peas, which insures their being well washed provided the spray has some force. When the

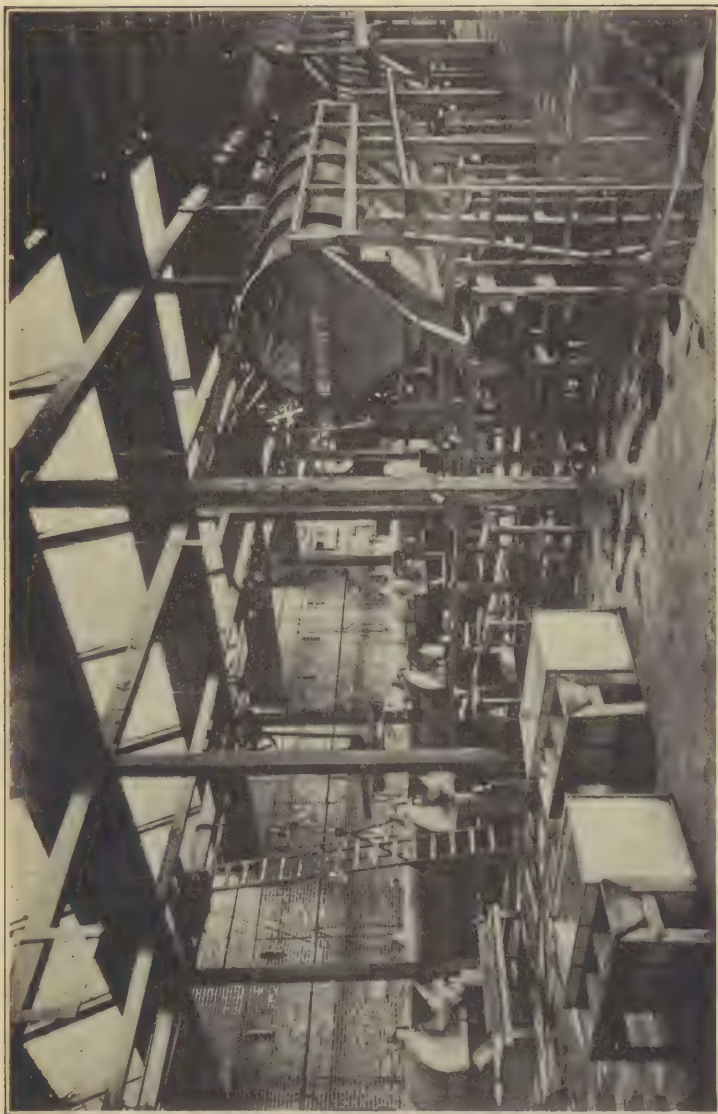


FIG. 22.—Pea cannery. Cylindrical sleeves may be seen at the right; blanching tanks at the left. (U. S. Department of Agriculture.)

weather is very warm and the peas accumulate more rapidly than they can be passed through the filler, it may be necessary to wash the shelled peas in cold water every few hours in order to prevent fermentation.

After the peas pass through the washer, they should be graded according to the degree of maturity or hardness. This is accomplished by passing them through tanks containing salt solutions of different densities. It has been found that the young tender peas will float in a salt solution somewhat heavier than water and those more mature will sink, while the very mature peas will sink in a heavy salt solution. Peas, therefore, may be sorted very readily into different grades according to their density by using different strengths of salt water. In practice three grades have been made. The first grade consists of all peas which will float in a solution having a specific gravity of 1.040. The second grade consists of those peas which will sink in a solution of this density but which will float in a solution having a specific gravity of 1.070. The third grade consists of the peas which will sink in the latter solution.

Grading. The grading of peas for quality is as sharp and clear as that for size. The lightest weight peas are the finest, being even in quality, succulent, and tender. The heaviest peas are the poorest, being uneven in quality, hard, overripe, and of bad color. The middle-weight peas are good, but harder than the first grade, of darker color, and not so uniform. These differences are most apparent before the canning is done, though they are readily distinguishable in the can, and also show on chemical examination.

A chemical examination of peas graded for quality as well as for size gave results as shown in the table on page 308.

The table shows more total solids and higher protein and starch content in the third-grade goods. This might be expected, as the third grade represents the more mature product. If canned peas were purchased for their nutritive properties only, then the third grade would be the preferable one to buy, but they are usually selected for their delicacy and flavor, which are found in the highest degree in the youngest and tenderest peas, or the first grade.

The grading for size is a very simple matter. The peas are passed over sieves, or into a revolving cylinder having four sections with perforations of different sizes. The perforations in the first sieve or section measure nine thirty-seconds of an inch in diameter. The peas which pass through this size opening are known as No. 1, or "petits pois." The next size of perforation is ten thirty-seconds of an inch in diameter, and the peas passing through are known as No. 2, "extra sifted," or "extra fins." The third size of perforation is eleven thirty-seconds of an inch, and the peas which pass through are known as No. 3, "sifted," or "fins." The last size is twelve thirty-

seconds of an inch, and the peas which pass through are known as No. 4, or "early June" peas. The peas which are too large to pass through this sieve go over the end and are known as No. 5, or "marrowfats." Some packers add one more sieve for late peas, with perforations thirteen thirty-seconds of an inch in diameter for the No. 5, and those which pass over this sieve are called No. 6, or "telephone peas." The sizes of these perforations are standard and in general use. Some packers have attempted to make sizes of their own by reaming out the holes, while others do not use all four sieves, but group two sizes together; and some peas are ungraded.

TABLE 39. CHEMICAL EXAMINATION OF PEAS GRADED FOR SIZE AND QUALITY

[Analyses made in the Division of Foods, Bureau of Chemistry.]

GRADE	TOTAL SOLIDS	ASH	PROTEIN	FIBER	PENTO- SANS	STARCH	SUCROSE	REDUCING SUGAR	UNDETER- MINED
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Petits pois									
First . .	14.23	1.03	3.44	1.68	0.75	5.57	0.72	0.00	1.04
Second . .	18.80	1.78	4.19	1.84	.92	8.53	.93	.00	.61
Third . .	18.04	1.82	4.41	2.28	.94	8.53	.81	.00	.35
Sifted :									
First . .	22.06	1.36	5.31	2.21	.96	10.23	.98	.00	1.01
Second . .	24.32	1.04	5.69	2.05	1.01	11.52	.57	.00	2.44
Third . .	27.74	1.37	5.63	2.18	1.50	13.52	.48	.00	3.06
Marrowfat :									
First . .	22.22	1.02	5.13	2.18	.98	10.48	.94	.00	1.49
Second . .	24.10	1.30	6.69	2.55	1.55	8.77	.63	.00	2.60
Third . .	27.15	2.03	5.94	2.00	1.27	12.91	.36	.00	2.63

After the peas have been graded into sizes they are usually run in thin layers over slowly moving belts, so that pieces of foreign material, broken, fully matured, and defective peas may be seen easily and removed. Low-grade peas are not so carefully picked over.

Blanching. There are two objects in blanching peas: (1) To remove the mucous substance from the outside and a part of the green coloring matter, so as to have a clear liquor in the can; and (2) to drive water into the peas, so that all will be tender.

In the young, juicy pea, the water content is at its maximum, so that the cleaning of the surface is all that is necessary. The time required for blanch-

ing is from one-half to one minute for No. 1 and No. 2, or "petits pois" and "extra sifted"; one and a half minutes for No. 3, or "sifted"; two minutes for No. 4, or "early June"; and two and one half minutes for No. 5, or "marrowfat" peas. To get the best results, peas which are very old and hard will need a blanch approximately five times as long as young peas of the corresponding grade, while those in the intermediate stages will require a blanch proportional to their development.

It is evident, therefore, that among peas that are good, but ungraded as to quality, there will be a greater or less number which will be hard because of under blanching, and some above size because of swelling during the blanching and after processing. There is no part of the work of canning peas which requires so much judgment as that of blanching if the best quality of goods is to be obtained.

When the peas leave the blancher, they are sometimes washed, and this is desirable in order to insure a clear liquor, especially if the peas have been blanched in wire baskets suspended in a tank of water.

The peas are filled into the cans by special machines, although in very small factories this may be done by hand. The modern machines do the work with a fair degree of accuracy, insuring a uniform quantity in each can, then adding liquor to fill, so that the caps will just go on.

A can is said to be well filled when the contents are within three eighths inch of the cap and the peas are just covered with liquor. Peas of excellent quality when covered to too great a depth with liquor deteriorate in appearance as can be determined by inserting a spoon and raising the peas gently but without appreciably disturbing the liquor. On the other hand, if there is not sufficient liquor to cover the peas, they are not generally attractive, and if very short of liquor, they become pasty. It is important, therefore, to use just enough liquor to cover the peas.

The No. 2 can generally used is popularly supposed to mean a 2-pound can, and is often so billed and referred to in market reports, but it does not hold 2 pounds and should be given its proper designation. The average fill of a can is such that after processing there will be 14 ounces of peas (400 grams) and $7\frac{1}{4}$ ounces (200 grams) of liquor. The can weighs 100 grams, making a total of 700 grams or 25 ounces. Any very marked deviation from these figures in the direction of reducing the proportion of peas would evidently be an adulteration with water, while any considerable increase in the proportion of peas would result in dryness. Cans containing only 11 or 12 ounces of peas are evidently short weight, though a customer cannot reasonably demand more than 15 ounces as a maximum and expect a good appearance.

A can of marrowfat or telephone peas will not weigh as much by about three fourths ounce (20 grams) as a can of the smaller-sized peas if the fill be

the same. The "sifted" pea, or No. 3 size, is the heaviest in the commercial grading. The "extra sifted" and the "petits pois" are the most expensive to the canner, and the tendency is to cut slightly in the weight, usually about three fourths of an ounce, although it is not uncommon to get cans from $1\frac{1}{2}$ to 2 ounces short on peas and correspondingly overweight on liquor.

The liquor used on peas is usually composed of water, salt, and sugar. At one time saccharin was used by many packers instead of sugar, but this practice has been almost entirely discontinued. The proportion of salt and sugar used varies greatly with the different packers. The lowest amounts given were 2 pounds of salt and 2 pounds of sugar to 100 gallons of water. The largest quantities used were 40 pounds of sugar and 16 pounds of salt per 100 gallons, while the average seems to be about 10 pounds of salt and 10 of sugar per 100 gallons of water. There is undoubtedly a tendency to reduce the amount of sugar used, and a few canners have left out both salt and sugar in some lots of peas to determine whether there is a market for an unseasoned product. The heavy sirups are used in the fancy and extra fancy brands of goods, the amount of sugar added to the sirup being often the only difference between the "superlatively good" and the "best." A fairly sweet sirup is sometimes used to give a weak, insipid, sugarless pea some semblance of quality, also to make the smooth pea as sweet as the sweet wrinkled variety. Analyses of 35 brands of peas purchased in the open market show the sugar content of the liquor to vary between 0.46 and 4.17 per cent, the average being 2.62 per cent. More sugar is found in eastern than in western packed peas, and in the domestic than in the foreign peas.

After being filled the can is passed through the wiping machine, the cap is put on and soldered in the automatic capper, the tipping follows, and then comes the final inspection in the water bath for leaks. At one factory the cans were passed through an exhauster for the double purpose of heating them uniformly and of driving off a certain characteristic odor which is objectionable.

Peas are processed in retorts under pressure, or in a solution of a calcium salt, in order to secure a temperature above that of boiling water. The time and temperature necessary to sterilize peas cannot be given with certainty because of the variation in factory practice and conditions which must be taken into account. If all factories handled their material promptly after being cut in the field, allowed no delays, such as standing on wagons or in piles to ferment, washed the peas well as soon as thrashed, graded them equally well, blanched them according to their needs, siruped and filled the cans the same, tipped the cans at the same temperature, and brought them to the process tank under like conditions, it would be possible to develop a process which might be safe for nearly all localities. Such ideal conditions

are not to be found in practice, and hence it is that one factory will employ a process of 240° F. for twenty minutes and do it successfully, while another must double the time before being reasonably successful in preventing spoilage. The effect of long processing is to cause a gradual decrease in the amount of free liquor in the can and to cause the peas to become sticky and adherent. This effect is shown in the following table:

TABLE 40. EFFECT OF VARIATION IN TIME OF PROCESSING ON LIQUOR CONTENT OF CAN

GRADE OF PEAS	GRAMS OF LIQUOR IN CANS PROCESSED FOR					
	20 Minutes	25 Minutes	30 Minutes	35 Minutes	50 Minutes	55 Minutes
Marrowfat . . .	215	212	190	165	70	60
Sifted	155	140	125	115	90	85
Petits pois . . .	155	150	125	115	60	50

The peas were sufficiently cooked in twenty-five minutes, and at each succeeding step they became thicker and stickier.

Examination of commercial canned peas. Peas were purchased from 15 groceries, representing 135 brands, 125 of which were of domestic production and 10 were imported. With the exception of 5 brands, the domestic peas were put up in standard No. 2 cans. The average weight of a can of peas was found to be 705 grams (25.2 ounces); the can, 103 grams (3.66 ounces); the peas, after the liquor was allowed to drain through a sieve for one minute, 394 grams (14 ounces); and the liquor, 208 grams (7.5 ounces). The variation in the total weight was between 650 and 735 grams; the can between 95 and 110 grams; the peas between 301 and 605 grams; and the liquor between 0 and 300 grams.

In the experimental work it was determined that a well-filled can should have 400 grams of peas and 200 grams of liquor, and the average for the commercial brands is essentially the same. When a can contains less than 385 grams, it is usually a slack fill, unless it contains marrowfat or telephone peas; if it contains more than 415 grams, the peas will be overcrowded or the liquor will be poor.

Spoilage. The spoilage in canned peas may be classified under three heads: (1) That due to leaks in the can; (2) to insufficient processing; and (3) to spoilage prior to the canning.

The spoilage due to leaks is largely a matter of carelessness in inspection.

Goods spoiled owing to insufficient processing are generally classed as "swells" and "sours." Formerly spoilage of this character was a serious matter, but the discovery of the cause and the means of prevention has decreased the loss from this source. At first No. 2 cans were boiled in open kettles from one to three hours, and the losses were not considered large, although the percentage would probably be considered high at this time. Later the processing was done in a retort at a higher temperature than that of boiling water, in order to reduce the time.

The spoilage occurring before the peas enter the can is due to allowing them to stand in piles, on the wagons or after thrashing, until they heat and start fermentation. If the peas are kept moving from the vine to the can, the spoilage from this source is very small.

Composition of legumes. The legumes are characterized by high protein content, as will readily be seen from the table beyond, where these and other vegetables are arranged alphabetically.

It will be seen that beans, lentils, and peas are not only richer in protein than other vegetables, but when dry they show higher percentages of protein than does fresh or canned meat. Since the dry legumes contain also considerable amounts of carbohydrate and small amounts of fat, they are in general of higher fuel value than meats. Meat fat enough to equal the dry legumes in energy value would be considerably below them in protein content.

Legumes also furnish important quantities of iron, phosphorus, and, to a less conspicuous degree, calcium. Notwithstanding the high protein content, the base-forming elements predominate.

Digestibility. Legumes in the green state seem to be more readily digested than dried legumes. The latter have been staple articles of diet since ancient times, but have almost always been considered more or less difficult of digestion. This impression is based more upon consciousness of the digestive process than upon measurements of actual losses in digestion, since the latter have been made only in recent years and show

the losses are not so large as might be supposed. Only the more recent experiments will be cited here.

Snyder, feeding a porridge made from dried peas as the principal part of a simple mixed diet, found the coefficient of digestibility for the peas alone: protein, 80 per cent, and carbohydrates, 96 per cent, — the amount of fat in the peas being too small for an accurate measurement of its digestibility.

Woods and Mansfield, in an experiment in which baked beans furnished about one fourth of the total protein, estimated the coefficient of digestibility of the protein of the beans at 78 per cent.

Wait, in a very extended series of digestion experiments,¹ in which legumes were fed as a prominent constituent of simple mixed diets, found the following coefficients of digestibility for the legumes:

	PROTEIN	CARBOHYDRATE
	<i>Per cent</i>	<i>Per cent</i>
Kidney beans	77	94
White beans	78	96
Cowpeas, "whippoorwill"	70	87
Cowpeas, "clay"	74	88
Cowpeas, "lady"	83	95

The comparative low digestibility of protein is not entirely a matter of the nature of the protein itself, but is at least partly due to the associated substances, for when the isolated protein is fed, a much higher coefficient is obtained.

Thus in a Japanese experiment cited by Oshima² in which a soy-bean preparation consisting chiefly of the bean protein was fed, the coefficient of digestibility for the protein was 96 per cent, and Salkowski found a coefficient of 94 per cent for the isolated protein of the horse bean.

¹ United States Department of Agriculture, Office of Experiment Stations, Bulletin 187.

² United States Department of Agriculture, Office of Experiment Stations, Bulletin 159.

Mendel and Fine,¹ feeding a man with a simple mixed diet of which 90 per cent of the protein was in the form of a commercial soy-bean meal "which betrayed no cellular structure under the microscope," found a coefficient of digestibility of 85.3 for the protein of the diet as against 87.9 and 88.0 for mixed diets in which the protein was furnished chiefly by meat and eggs.

Utilization in metabolism. In the experiment of Mendel and Fine just quoted, the nitrogen balance showed a smaller storage of nitrogen during the soy-bean period than during the preceding and following periods, in which the source of protein was meat and eggs, indicating a slightly less favorable utilization of the legume protein in metabolism. With the exception of the early work of Rutgers² this appears to be the only investigation in which nitrogen balance was studied. Osborne and Mendel have, however, shown that young rats can make active growth and normal development on a diet with glycinin of soy-bean as the sole protein.

TABLE 41. AMINO ACIDS FROM PROTEINS OF LEGUMES (OSBORNE)

	PHASEOLIN (Bean)	VIGNIN (Cowpea)	LEGUMIN (Pea)	VICILIN (Pea)	LEGUMELIN (Pea)
Glycin . . .	0.55	0.00	0.38	0.00	0.50
Alanin . . .	1.80	0.97	2.08	0.50	0.92
Valin . . .	1.04	0.34	—	0.15	0.69
Leucin . . .	9.65	7.82	8.00	9.38	9.63
Prolin . . .	2.77	5.25	3.22	4.06	3.96
Phenylalanin .	3.25	5.27	3.75	3.82	4.79
Aspartic acid .	5.24	3.97	5.30	5.30	4.11
Glutamic acid .	14.54	16.89	16.97	21.34	12.96
Serin . . .	0.38	—	0.53	—	—
Tyrosin . . .	2.84	2.26	1.55	2.38	1.56
Arginin . . .	4.87	7.20	11.71	8.91	5.45
Histidin . . .	2.62	3.08	1.69	2.17	2.27
Lysin . . .	4.58	4.28	4.98	5.40	3.03
Ammonia . .	2.06	2.32	2.05	2.03	1.26
Tryptophan . .	present	present	present	present	present
Summation .	56.19	59.65	62.21	65.44	51.13

¹ Journal of Biological Chemistry, Vol. 10, pages 435-438.

² Cited in *Chemistry of Food and Nutrition*, page 308.

The chemical nature of legume proteins as indicated by the amino acids obtained on hydrolysis has been investigated by Osborne with the results as shown on previous page.

In these cases no attempt was made to determine cystin.

These results indicate that the proteins of the legumes are very similar in chemical constitution to those of meat.

Physiological effects of peas greened with copper. Canned peas, particularly those prepared in France for export to England and to the United States, have to a large extent been treated with small quantities of copper salts to preserve or intensify the green color.

Under the Food and Drugs Act, the question of the wholesomeness of vegetables thus greened with copper was raised and was referred to the Referee Board of Consulting Scientific Experts for investigation, with the result that the importation of such coppered vegetables has been forbidden. The following abstract of the report rendered by the Referee Board is from the Experiment Station Record published by the United States Department of Agriculture and is here given verbatim to show the experimental methods employed and the reasoning by which the conclusion of the Board was reached.

Influence of vegetables greened with copper salts on the nutrition and health of man. I. REMSEN ET AL. (*U. S. Dept. Agr. Rpt.* 97, pp. 461).—This report of the Referee Board of Consulting Scientific Experts presents in detail and discusses the experimental data obtained in the four series of investigations, summarized below:

Action of coppered vegetables on the health and nutrition of men, A. E. Taylor (pp. 9–208).—In these experiments normal young men were given mixed diets containing measured quantities of canned vegetables (notably peas) colored by copper, and the usual means were taken for measuring and analyzing the food and excreta during a period of about 3 months. The author summarizes the results as follows:

“The sole results that are clinically apparent in the subjects who ingested coppered vegetables in amount carrying up to 0.025 gm. of copper per day were possibly slight disturbance of the alimentary tract in one; possibly a slight increase in unresorbed nitrogen in a second; and possibly a slight reduc-

tion in the retention of nitrogen in the same individual. These data are of very doubtful value. The important fact that has developed in these investigations is the retention of copper. In all the subjects there was retention of copper, varying from individual to individual; in 1 subject very high considering the dosage, in 2 marked, in others low. These data parallel those that have been obtained by Professor Chittenden in animals. And, by analogy, we may infer that the retention was in the liver. By further analogy with lead and mercury, we may infer that a later redistribution may occur throughout the body. I do not believe such a retention of a heavy metal can be a negligible matter even in the complete absence of present symptoms referable thereto; the whole tenor of the pharmacology of the heavy metals is contrary to such an interpretation. It will be only safe to exclude the retention of a metal like copper from the body. The retention in the case of the subjects of this experiment followed ingestions of copper that could not be called large. And apparently such retention might be expected to follow any ingestion of coppered vegetables. Under these circumstances the ingestion of vegetables colored with copper constitutes a menace to health."

Investigations of the effects of foods containing copper compounds on the general health and metabolism of man, J. H. Long (pp. 209-430). — The method of experimenting was similar to that used in the series conducted by Taylor, but the tests were continued for 4 months, made up of periods in which the copper dosage was varied. The author reached the following conclusions:

"During the lower dosage periods with copper in peas our records point to nothing which may be clearly applied in showing a harmful action of the metal. It appears that 100 gm. daily of peas containing 10 mg. of copper occasioned no marked disturbance beyond the distaste for the peas themselves. . . .

"About the only conclusion that we may legitimately draw from our low dosage experiments is that it may be difficult to feed enough peas — and this may be even more truly the case with certain other vegetables — to ingest copper in amount sufficient to produce a harmful action, as shown by clinical and metabolism observations.

"On the other hand, it is certainly true that copper sulphate as ingested with milk or beer through periods of some weeks is far from being harmless or free from easily observed effects. The copper in this form has apparently a physiological action distinct from that in the peas, and is unquestionably more active. . . .

"The addition of copper salts to peas and other vegetables has unquestionably the effect of suggesting to the user greater freshness than may be actually the case. While a very old pea may not be easily colored, it is true that peas which have begun to harden, and are far from the young or fresh

stage, may be given enough copper materially to brighten their appearance. In this way it is clear, a certain kind of inferiority is covered up. . . .

"If, in the coppering of vegetables, an excess of the metallic salt is employed, an injurious action of this copper may certainly be affirmed. This danger is not a remote one, as a high copper content of cans of peas, with copper in the liquor as well as in the solid, has frequently been reported. In our laboratory experiments we have been able to show that an excessive amount of copper may be easily added and loosely held, in some other than the ordinary chlorophyll combination. As long as this possibility is present the whole coloring process, involving the use of a heavy metallic salt, must be looked upon with distrust, and must be considered as highly objectionable."

Absorption and distribution of copper when coppered vegetables are eaten, R. H. Chittenden (pp. 431-448). — In these experiments dogs and monkeys were fed with coppered vegetables in order to ascertain "how far copper is absorbed and to what degree it is deposited in the organs and tissues of the body when taken in small doses in combination with a food such as canned peas."

The conclusions of the author are that "when coppered vegetables are eaten with the food a certain proportion of the copper is absorbed and may be temporarily deposited in the liver. Even when taken in very small amounts, copper ingested in this way is prone to be absorbed in some degree, and thus constitutes a menace to good health. The conclusion seems obvious that vegetables which have been greened with copper salts are adulterated, because they contain an added poisonous or deleterious ingredient which may render such articles of food injurious to health, whether taken in large quantities or in small quantities. In any event, there is an element of danger in coppered foods which, from a physiological standpoint, should not be ignored."

Histological examination of the tissues of dogs and monkeys, T. Smith (pp. 449-461). — This report gives the results of autopsies made on animals used in the feeding experiments conducted by Chittenden.

"A comparison of the gross and minute pathological conditions found in the 8 dogs shows a relatively slight yield from these methods of inquiry. A few facts, however, seem worthy of note.

"There has been no noticeable influence of the copper salts on the parasites in the digestive tract. Thus, dogs Nos. 1 and 3 were from the same litter and probably infested alike with worms at the start. But the autopsy showed no difference, although No. 3 had been fed with coppered peas and No. 1 with uncoppered peas. Parasites were also present in the other dogs fed with coppered peas. . . . In general it can be stated that the feeding

with coppered peas did not have any decided vermifuge action. . . . Even the copper sulphate did not completely remove intestinal parasites.

"Very little, if any, appreciable differences were found between the controls on the one hand (Nos. 1 and 2) and the dogs fed with coppered peas on the other (Nos. 3 to 6). There was some fat in the liver of No. 3 as compared with his (control) brother No. 1. More than this cannot be stated. There is, however, a distinction to be drawn between the dogs fed with coppered peas and those fed with copper sulphate. No. 8 was chloroformed before the close of the experiment because ill. In both No. 7 and No. 8 there was present an interstitial inflammation of the kidneys localized in the cortex, which was absent in all the others. The kidney lesions in Nos. 1 and 3 were, as already stated, due to parasites. In No. 8 there was also other lesions (extensive, fresh pigment in the spleen, leucocytosis)."

In the case of monkeys "the microscopic examination, as far as it went, did not reveal any differences between control and treated monkeys. It would seem as if this species of animal was better able to neutralize the poisonous action of copper sulphate than the dog."

From a study of these 4 reports, the Referee Board reached the following conclusion:

"Copper salts used in the coloring of vegetables as in commercial practice cannot be said to reduce, or lower, or injuriously affect the quality or strength of such vegetables, as far as the food value is concerned.

"Copper salts used in the greening of vegetables may have the effect of concealing inferiority, inasmuch as the bright green color imparted to the vegetables simulates a state of freshness they may not have possessed before treatment.

"In attempting to define a large quantity of copper, regard must be had to the maximum amount of greened vegetables which might be consumed daily. A daily dose of 100 gm. of coppered peas or beans, which are the most highly colored vegetables in the market, would not ordinarily contain more than 100 to 150 mg. of copper. Such a bulk of greened vegetables is so large, however, that it would hardly be chosen as a part of a diet for many days in succession. Any amount of copper above 150 mg. daily may therefore be considered excessive in practice. A small quantity is that amount which, in the ordinary use of vegetables, may be consumed over longer periods. From this point of view, 10 to 12 mg. of copper may be regarded as the upper limit of a small quantity.

"It appears from our investigations that in certain directions even such small quantities of copper may have a deleterious action and must be considered injurious to health."

Potatoes, Sweet Potatoes, and Yams

Langworthy estimates that potatoes, sweet potatoes, and yams furnish 3.8 per cent of the protein, 0.3 per cent of the fat, and 8.3 per cent of the carbohydrate of the average American dietary.

Census reports show for 1909 a production in the United States of 389,000,000 bushels of potatoes valued at \$166,000,000 and 59,232,000 bushels of sweet potatoes and yams valued at \$35,429,000.

Since relatively small quantities of potatoes or sweet potatoes are used for stock feeding or for the manufacture of starch or alcohol, in the United States, the yearly consumption as food must be nearly the amounts produced or about 4 bushels per capita.

The potato is a native of America, said to have been first found in Chili, and it was not commonly cultivated in Europe until the eighteenth century.

At present potatoes are raised in large quantities in Europe both for food, for industrial purposes such as starch, glucose, and alcohol manufacture, and for stock-feeding. Estimates of per capita consumption of potatoes as human food in European countries are not at hand.

For description of the potato industry, the reader must be referred to books on agriculture and horticulture. A very comprehensive discussion will be found in "The Potato Industry of Colorado," published as Bulletin 158 of the Agricultural Experiment Station, Fort Collins, Colorado.

Composition. The averages of American analyses are tabulated with those of other vegetables beyond (Table 42). In round numbers the potato contains 2 to 2.5 per cent of protein; 18 to 20 per cent of carbohydrates, chiefly starch; almost no fat; about 1 per cent of ash; and 75 to 79 per cent of water. Or, in still simpler terms, about three fourths of the potato is

water, and of the solids there is about eight times as much starch as protein, a little fiber, a very little fat, and an amount of ash which is relatively large in comparison with most other foods.

Digestion experiments with potatoes fed in considerable quantity to healthy men have been reported by Rubner, by Snyder, and by Bryant and Milner, who found respectively 68, 72, and 73 per cent of the protein and 92, 93, and 99 per cent of the carbohydrate utilized. Thus the fuel value of the potato is as well utilized as that of most foods, and at least 70 per cent of the protein is digested and absorbed.

The nutritive economy of potatoes as food will be discussed later in this chapter.

Structure of the potato. Since the potato tuber is in reality a thickened stem, it can be seen to consist of fairly definite anatomical parts. The following description is taken from Langworthy, *Farmers' Bulletin 295* of the United States Department of Agriculture:

The outer skin of the tuber consists of a thin, grayish brown, corky substance and corresponds roughly to the bark of an overground stem. If a crosswise section of a raw potato is held up to the light, three distinct parts besides the skin may be seen. The outermost one is known as the cortical layer and may be from 0.12 to 0.5 inch in thickness. This layer is slightly colored, the tint varying with the kind, and turns green if exposed to the light for some time, thus showing its relation to the tender green layer beneath the bark of overground stems. It is denser than the other parts of the potato and contains many fibrovascular bundles, especially on the inner edge, where a marked ring of them plainly separates this layer from the next. The interior or flesh of the tuber is made up of two layers known as the outer and inner medullary areas. The outer one forms the main bulk of a well-developed potato and contains the greater part of the food ingredients. The inner medullary area, some-

times called the core, appears in a cross section of the tuber to spread irregular arms up into the outer, so that its outline roughly suggests a star. It contains slightly more cellulose

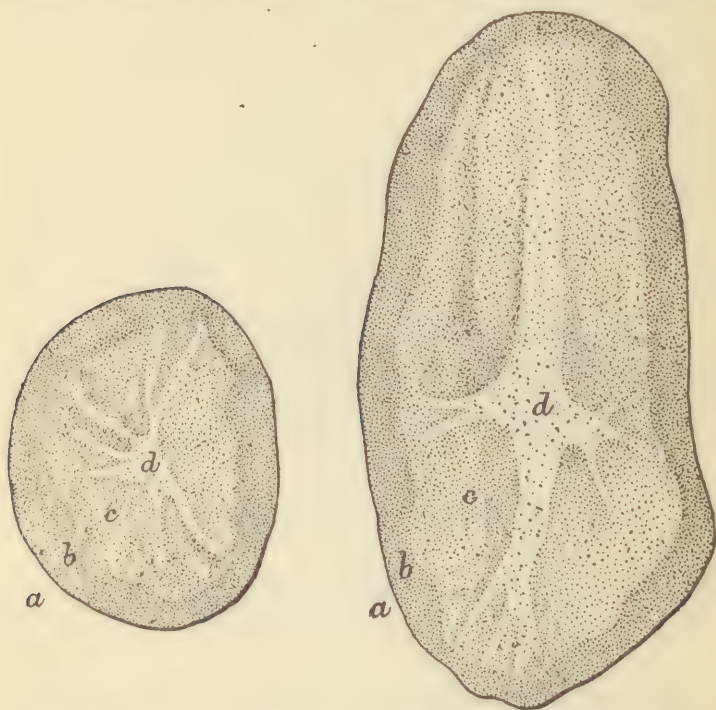


FIG. 23. — Transverse and longitudinal sections of the potato: *a*, skin; *b*, cortical layer; *c*, outer medullary layer; *d*, inner medullary layer. (U. S. Department of Agriculture.)

and less water and nutrients than the outer medullary portion. These four parts of the tuber are shown in Fig. 23.

The corky skin of the potato makes up about 2.5 per cent of the whole, and the cortical layer 8.5 per cent, leaving 89 per cent for the medullary areas. . . .

As in all other plant forms, the framework of the tuber is made up of cellulose. Cellulose forms the walls of a network of cells, which in turn form the body of the tuber. These cells vary in shape and size in different sections of the tuber according to the part they play in its life. In the flesh they serve mainly for storage, and in them lie the starch grains. (See Fig. 24.)

In young tubers there is a larger proportion of sugars and less starch than when they have become mature. As the tuber lies in the ground the starch content increases. When it begins to sprout, however, part of the starch is converted by a ferment in the tuber into soluble glucose. Thus, young or early potatoes

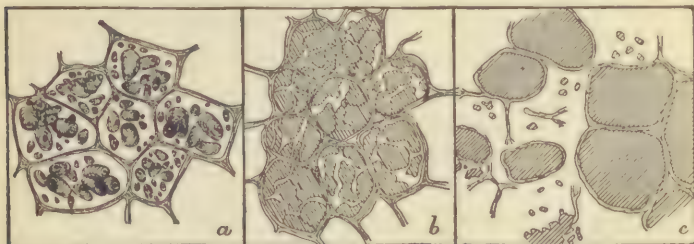


FIG. 24. — Changes of potato starch cells in cooking: *a*, raw; *b*, partially cooked; *c*, thoroughly cooked. (U. S. Department of Agriculture.)

and old ones both have a smaller proportion of starch and more soluble sugars than well-grown but still fresh tubers. The effect of cooking on the mechanical condition of the potato cells is shown in Fig. 24.

The figures show the great changes in the mechanical condition of the potato flesh under the influence of heat, the broken cell walls and the increased bulk of the starch grains being particularly noticeable.

The **sweet potato** plant (*Ipomœa batata* or *Batatas edulis*) is not closely related to the white potato, botanically, but in composition and use as food the tubers are much alike, the sweet potato having in general about the same nutrients as the white potato and in addition from 5 to 8 per cent of sugar.

Recently the canning of sweet potatoes has developed into an important industry, and has made these vegetables available as a staple food throughout the year.

For further accounts of potatoes and sweet potatoes, reference may be made to Farmers' Bulletins 295 and 324 of the United States Department of Agriculture.

. Other Vegetables

The Census Bureau reports that except for potatoes, sweet potatoes, and yams, which are generally grown in considerable quantities, it is practically impossible to obtain a correct total of the acreage, production, or value of individual kinds of vegetables. The value of vegetables reported for the census year 1909 amounted to \$216,257,000 (exclusive of potatoes, sweet potatoes, and yams and dried beans and peas).

The largest industry here involved is that of canning tomatoes, of which there were put up in canning factories in the United States, in the census year 1909, a total of 12,800,000 cases of 12 cans each. This is exclusive of the tomatoes canned at home and also of the manufacture of ketchups, sauces, etc.

The canning of tomatoes presents no special features requiring detailed description. The acidity of the material makes it possible to sterilize the canned product with greater certainty and at a lower temperature than in the case of peas or of canned meat.

The Board of Food and Drug Inspection has ruled that the water naturally present in tomatoes is ample to serve as a medium for the cooking and packing processes involved in tomato canning, and that the addition either of water or of juice in the canning of tomatoes shall be judged an adulteration.

In the absence of data which would permit a discussion of the relative amounts grown and used, it seems unnecessary here to enter into any description of the sources and technology of the different kinds of vegetables.

Composition of Vegetables

The average composition of practically all vegetables used for food to any important extent in the United States is shown in the following table, which is based chiefly on analyses compiled by Atwater and Bryant, and published by the United States Department of Agriculture:

TABLE 42. AVERAGE COMPOSITION OF AMERICAN VEGETABLES¹

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Artichokes	2	—	79.5	2.6	.2	16.7	.8	1.0	358
Asparagus, fresh . .	3	—	94.0	1.8	.2	3.3	.8	.7	101
Asparagus, cooked . .	1	—	91.6	2.1	3.3	2.2	—	.8	213
Beans, butter, green:									
Edible portion . . .	1	—	58.9	9.4	.6	29.1	—	2.0	723
As purchased . . .	1	50.0	29.4	4.7	.3	14.6	—	1.0	361
Beans, dried	11	—	12.0	22.5	1.8	50.0	(⁴)4.4	3.5	1504
Beans, frijoles (New Mexico)	4	—	7.5	21.9	1.3	65.1	—	4.2	1633
Beans, Lima, dried . .	4	—	10.4	18.1	1.5	65.0	—	4.1	1586
Beans, Lima, fresh:									
Edible portion . . .	1	—	68.5	7.1	.7	22.0	1.7	1.7	557
As purchased . . .	—	55.0	30.8	3.2	.3	9.9	.8	.8	250
Beans, mesquite, dry	1	—	4.8	12.2	2.5	77.1	—	3.4	1723
Beans, string, cooked:									
Edible portion . . .	1	—	95.3	.8	1.1	1.9	—	.9	94
Beans, string, fresh:									
Edible portion . . .	5	—	89.2	2.3	.3	7.4	(²)1.9	.8	189
As purchased . . .	—	7.0	83.0	2.1	.3	6.9	1.8	.7	176

¹ Such vegetables as potatoes, squash, beets, etc., have a certain amount of inedible material, skin, seeds, etc. The amount varies with the method of preparing the vegetables, and cannot be accurately estimated. The figures given for refuse of vegetables, fruits, etc., are assumed to represent approximately the amount of refuse in these foods as ordinarily prepared.

TABLE 42. AVERAGE COMPOSITION OF AMERICAN VEGETABLES—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Beets, cooked	1	—	88.6	2.3	.1	7.4	—	1.6	180
Beets, fresh:									
Edible portion . . .	24	—	87.5	1.6	.1	9.7	(18) .9	1.1	209
As purchased . . .	—	20.0	70.0	1.3	.1	7.7	—	.9	167
Cabbage:									
Edible portion . . .	16	—	91.5	1.6	.3	5.6	(8) 1.1	1.0	143
As purchased . . .	—	15.0	77.7	1.4	.2	4.8	—	.9	121
Cabbage, curly	1	—	87.3	4.1	.6	6.2	—	1.8	211
Cabbage sprouts:									
Edible portion . . .	1	—	88.2	4.7	1.1	4.3	—	1.7	208
As purchased . . .	1	61.8	33.7	1.8	.4	1.7	—	.6	79
Carrots, fresh:									
Edible portion . . .	18	—	88.2	1.1	.4	9.3	(15) 1.1	1.0	205
As purchased . . .	—	20.0	70.6	.9	.2	7.4	—	.9	159
Carrots, evaporated . .	1	—	3.5	7.7	3.6	80.3	—	4.9	1743
Cauliflower	2	—	92.3	1.8	.5	4.7	(1) 1.0	.7	138
Celery:									
Edible portion . . .	5	—	94.5	1.1	.1	3.3	—	1.0	84
As purchased . . .	—	20.0	75.6	.9	.1	2.6	—	.8	68
Chard	2	—	89.6	3.2	.6	5.0	—	1.6	173
Collards:									
Edible portion . . .	2	—	87.1	4.5	.6	6.3	—	1.5	220
Corn, green:									
Edible portion . . .	3	—	75.4	3.1	1.1	19.7	(1) .5	.7	459
As purchased . . .	—	61.0	29.4	1.2	.4	7.7	—	.3	178
Cucumbers:									
Edible portion . . .	4	—	95.4	.8	.2	3.1	(2) .7	.5	79
As purchased . . .	—	15.0	81.1	.7	.2	2.6	—	.4	68
Eggplant, edible portion	1	—	92.9	1.2	.3	5.1	.8	.5	127
Greens, beet, cooked . .	1	—	89.5	2.2	3.4	3.2	—	1.7	237
Greens, dandelion, as purchased	1	—	81.4	2.4	1.0	10.6	—	4.6	277
Greens, turnip-salad . .	2	—	86.7	4.2	.6	6.3	—	2.2	215
Kohl-rabi, edible portion	2	—	91.1	2.0	.1	5.5	1.3	1.3	140

TABLE 42. AVERAGE COMPOSITION OF AMERICAN VEGETABLES—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Leeks:									
Edible portion . . .	1	—	91.8	1.2	.5	5.8	—	.7	147
As purchased . . .	1	15.0	78.0	1.0	.4	5.0	.6	.6	125
Lentils, dried . . .	3	—	8.4	25.7	1.0	59.2	—	5.7	1581
Lettuce:									
Edible portion . . .	8	—	94.7	1.2	.3	2.9	(7) .7	.9	87
As purchased . . .	—	15.0	80.5	1.0	.2	2.5	—	.8	72
Mushrooms . . .	11	—	88.1	3.5	.4	6.8	(8) .8	1.2	203
Okra:									
Edible portion . . .	2	—	90.2	1.6	.2	7.4	(1) 3.4	.6	172
As purchased . . .	—	12.5	78.9	1.4	.2	6.5	—	.5	152
Onions, fresh:									
Edible portion . . .	15	—	87.6	1.6	.3	9.9	(7) .8	.6	220
As purchased . . .	—	10.0	78.9	1.4	.3	8.9	—	.5	200
Onions, cooked . . .	1	—	91.2	1.2	1.8	4.9	—	.9	184
Onions, green (New Mexico):									
Edible portion . . .	2	—	87.1	1.0	.1	11.2	—	.6	225
As purchased . . .	—	51.0	42.6	.5	.1	5.5	—	.3	113
Parsnips:									
Edible portion . . .	3	—	83.0	1.6	.5	13.5	(1) 2.5	1.4	294
As purchased . . .	—	20.0	66.4	1.3	.4	10.8	—	1.1	236
Peas, dried . . .	8	—	9.5	24.6	1.0	62.0	(2) 4.5	2.9	1612
Peas, green:									
Edible portion . . .	5	—	74.6	7.0	.5	16.9	(1) 1.7	1.0	454
As purchased . . .	—	45.0	40.8	3.6	.2	9.8	—	.6	251
Peas, green, cooked . . .	1	—	73.8	6.7	3.4	14.6	—	1.5	525
Peas, sugar, green . . .	1	—	81.8	3.4	.4	13.7	1.6	.7	327
Cowpeas, dried . . .	13	—	13.0	21.4	1.4	60.8	4.1	3.4	1550
Cowpeas, green, edible portion . . .	1	—	65.9	9.4	.6	22.7	—	1.4	603
Potatoes, raw or fresh:									
Edible portion . . .	136	—	78.3	2.2	.1	18.4	(58) .4	1.0	378
As purchased . . .	—	20.0	62.6	1.8	.1	14.7	—	.8	302

TABLE 42. AVERAGE COMPOSITION OF AMERICAN VEGETABLES—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Potatoes, evaporated . .	3	—	7.1	8.5	.4	80.9	—	3.1	1638
Potatoes, cooked, boiled	11	—	75.5	2.5	.1	20.9	(1).6	1.0	429
Potatoes, cooked, chips	2	—	2.2	6.8	39.8	46.7	—	4.5	2598
Potatoes, cooked, mashed, and creamed	4	—	75.1	2.6	3.0	17.8	—	1.5	493
Potatoes, sweet, raw, or fresh:									
Edible portion . .	95	—	69.0	1.8	.7	27.4	(88)1.3	1.1	558
As purchased . . .	—	20.0	55.2	1.4	.6	21.9	—	.9	447
Potatoes, sweet, cooked	1	—	51.9	3.0	2.1	42.1	—	.9	903
Pumpkins:									
Edible portion . .	3	—	93.1	1.0	.1	5.2	1.2	.6	117
As purchased . . .	—	50.0	46.5	.5	.1	2.6	—	.3	59
Radishes:									
Edible portion . .	4	—	91.8	1.3	.1	5.8	(2).7	1.0	133
As purchased . . .	—	30.0	64.3	.9	.1	4.0	—	.7	91
Rhubarb:									
Edible portion . .	2	—	94.4	.6	.7	3.6	(1)1.1	.7	105
As purchased . . .	—	40.0	56.6	.4	.4	2.2	—	.4	63
Rutabagas:									
Edible portion . . .	5	—	88.9	1.3	.2	8.5	1.2	1.1	186
As purchased . . .	—	30.0	62.2	.9	.1	6.0	—	.8	129
Sauerkraut	2	—	88.8	1.7	.5	3.8	—	5.2	120
Spinach, fresh . . .	3	—	92.3	2.1	.3	3.2	.9	2.1	109
Spinach, cooked . . .	1	—	89.8	2.1	4.1	2.6	—	1.4	252
Squash:									
Edible portion . .	10	—	88.3	1.4	.5	9.0	(5).8	.8	209
As purchased . . .	—	50.0	44.2	.7	.2	4.5	—	.4	103
Tomatoes, fresh . . .	27	—	94.3	.9	.4	3.9	(22).6	.5	104
Tomatoes, dried . . .	1	—	7.3	12.9	8.1	62.3	—	9.4	1695
Turnips:									
Edible portion . .	19	—	89.6	1.3	.2	8.1	(9)1.3	.8	178
As purchased . . .	—	30.0	62.7	.9	.1	5.7	—	.6	124

TABLE 42. AVERAGE COMPOSITION OF AMERICAN VEGETABLES — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
VEGETABLES, CANNED									
Artichokes	3	—	92.5	.8	—	5.0	.6	1.7	105
Asparagus	14	—	94.4	1.5	.1	2.8	.5	1.2	82
Beans, baked	21	—	68.9	6.9	2.5	19.6	(12) 2.5	2.1	583
Beans, string	29	—	93.7	1.1	.1	3.8	(18) .5	1.3	93
Beans, little green . . .	1	—	93.8	1.2	.1	3.4	.6	1.5	87
Beans, wax	1	—	94.6	1.0	.1	3.1	.6	1.2	78
Beans, haricots verts . .	7	—	95.2	1.1	.1	2.5	.5	1.1	69
Beans, haricots flageolets	3	—	81.6	4.6	.1	12.5	1.0	1.2	314
Beans, Lima	16	—	79.5	4.0	.3	14.6	(15) 1.2	1.6	350
Beans, red kidney, shelled	1	—	72.7	7.0	.2	18.5	1.2	1.6	471
Brussels sprouts, as purchased	1	—	93.7	1.5	.1	3.4	.5	1.3	93
Corn, green ¹	52	—	76.1	2.8	1.2	19.0	(43) .8	.9	445
Corn and tomatoes . . .	2	—	87.6	1.6	.4	9.6	.5	.8	220
Macedoine (mixed vegetables)	5	—	93.1	1.4	—	4.5	.6	1.0	107
Okra ²	4	—	94.4	.7	.1	3.6	.7	1.2	82
Peas, green ³	88	—	85.3	3.6	.2	9.8	(83) 1.2	1.1	251
Potatoes, sweet	2	—	55.2	1.9	.4	41.4	(1) .8	1.1	802
Pumpkins	7	—	91.6	.8	.2	6.7	(5) 1.1	.7	144
Squash	5	—	87.6	.9	.5	10.5	(2) .7	.5	227
Succotash	12	—	75.9	3.6	1.0	18.6	(10) .9	.9	444
Tomatoes ⁴	19	—	94.0	1.2	.2	4.0	(11) .5	.6	103
PICKLES, CONDIMENTS, ETC.									
Catsup, tomato	2	—	82.8	1.5	.2	12.3	—	3.2	259
Horseradish	2	—	86.4	1.4	.2	10.5	—	1.5	224

¹ Thirty-two samples contained an average of 0.4 per cent NaCl.² Three samples contained an average of 1.1 per cent NaCl.³ Eighty samples contained an average of 0.7 per cent NaCl.⁴ Seven samples contained an average of 0.1 per cent NaCl.

TABLE 42. AVERAGE COMPOSITION OF AMERICAN VEGETABLES—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
PICKLES, CONDIMENTS, ETC.									
Olives, green:									
Edible portion . . .	1	—	58.0	1.1	27.6	11.6	—	1.7	1357
As purchased . . .	1	27.0	42.3	.8	20.2	8.5	—	1.2	994
Olives, ripe:									
Edible portion . . .	1	—	64.7	1.7	25.9	4.3	—	3.4	1166
As purchased . . .	1	19.0	52.4	1.4	21.0	3.5	—	2.7	947
Peppers (paprica), green, dried	1	—	5.0	15.5	8.5	63.0	—	8.0	1771
Peppers, red chili . . .	5	—	5.3	9.4	7.7	70.0	—	7.6	1756
Pickles, cucumber . . .	3	—	92.9	.5	.3	2.7	—	3.6	66
Pickles, mixed, as purchased	1	—	93.8	1.1	.4	4.0	—	.7	109

The nutritive economy of vegetables and their place in the diet is discussed in connection with fruits and nuts further on in this chapter.

Fruits and Nuts

Census reports show for 1909 a production of fruits and nuts (exclusive of peanuts) in the United States amounting in value to \$222,024,000.

Of this, "small fruits" contributed \$29,974,000; orchard fruits, \$140,867,000; grapes, \$22,028,000; citrus fruits, \$22,711,000; other tropical and subtropical fruits, \$1,995,000; nuts, \$4,448,000.

The value of the peanut crop was reported at \$18,272,000.

Of the "small fruits," strawberries represented over half the total acreage and about three fourths of the total value; next

in order of value of product among the small fruits follow raspberries, blackberries (and dewberries), currants, gooseberries, and cranberries.

Among the orchard fruits, apples are much the most important, being about three fifths of the total. Peaches and nectarines rank next, followed by plums and prunes, pears, cherries, and

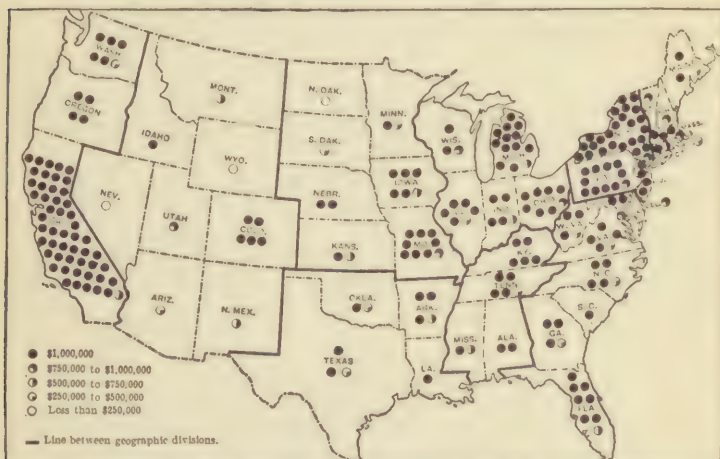


FIG. 25. — Production of fruits and nuts in the United States. (Census of 1910.)

apricots and quinces in the order named. From 150,000,000 to 175,000,000 bushels of apples are produced in the United States each year.

Among the citrus fruits, oranges lead with a production of 19,487,481 boxes valued at \$17,566,464; then follow lemons with 2,770,313 boxes valued at \$2,993,738, and grapefruit (pomeloes) with 1,189,250 boxes valued at \$2,060,610. The production of grapefruit showed a very rapid increase between 1900 and 1910. The production of the other citrus fruits, limes, tangerines, mandarins, and kumquats is so far below that of oranges, lemons, and grapefruit as to play no significant part in the fruit supply.

Olive culture in the United States is practically confined to California and Arizona. The crop of 1909, 16,405,000 pounds, was more than three times as great as that of 1899.

The widely varying extent to which the different states contribute to the fruit and nut supply is shown by Fig. 25.

The growing, packing, and ordinary handling of fruits is discussed in works on horticulture and need not be taken up here.

There are, however, certain modern practices in the fruit industry which may be worthy of note because of their influence in systematizing the fruit supply, particularly in facilitating the marketing of California fruit in the eastern cities. The following notes on this industry are based on the account given in Powell's *Coöperation in Agriculture*:

California oranges and lemons are handled differently from any other American fruit. They are staple products ripening less quickly than most fruits, and the distribution and marketing have been reduced to a systematic basis. The crop now amounts to about 50,000 carloads, or 20,000,000 boxes, a year. This is the product of more than 12,000 growers, about three fourths of whom are organized into coöperative associations, sixty-five per cent of which are federated into the California Fruit-growers' Exchange. These associations build packing-houses in which the fruit of the members is assembled, graded, packed, and made ready for shipment, these operations being usually done at cost prorated on the number of boxes shipped by each grower. On the average one packing-house suffices for about 500 acres of orange or lemon groves. Many of the associations pick the fruit, and some of them prune and fumigate the trees for the members. The associations have brands for each grade of fruit, and when a carload is ready for shipment, it is marketed in coöperation with the district exchange of which the association is a member through the agents and facilities provided by the central exchange. The local associations have (1913) formed seventeen district exchanges. Among other functions, it is the duty of the district exchange to act as the business medium between the local associations and the central exchange, to order cars and see that they are placed by the railroads at the various packing-houses, to keep records, and to distribute to the local associations the information gathered by the central exchange. The function of this central exchange is to furnish marketing facilities for the district exchanges and associations at a *pro rata* share of

the cost. The exchange maintains its own agents in the principal markets in the United States and Canada, supervises these agents, gathers daily information through them of conditions in each market, and furnishes this information daily in bulletin form to the associations. The central exchange also performs other functions for the protection of its members and the extension of the industry, but makes no attempt to regulate shipments or to influence prices. Each shipper has entire control of its own shipments, reserving the right of free competition with all other shippers even within the same organization, and the agent in the market acts directly under the order of the shipper. There is no uniformity of price among the different brands, each brand selling on its own merits. This system is the result of twenty years' development and has been a large factor in changing the status of the orange from a luxury to a staple article of diet.

Formerly about \$1,000,000 worth of oranges and lemons were lost yearly by decay during shipment to market from California. This loss has been practically eliminated by improved methods of picking and handling the fruit. At the same time the introduction of "precooling" makes it possible to market a fruit which is of superior quality through having come more nearly to maturity before picking.

The fruit is cooled to 35° F. before shipping, loaded in cars having bunkers filled with ice, and shipped thus without reaching to any part of the United States. The cold storage plants operated in connection with the pre-cooling system make possible also a better classification of the fruit in shipment from the larger accumulation of packed fruit in the storage rooms.

The production of dried fruit is a very large industry in California, where many thousands of tons of peaches, apricots, prunes, and raisins are dried annually, the wholesale value of the combined product (at point of production) being estimated at about \$20,000,000 a year.

During most of the year California dried fruit is much cheaper (in proportion to the solids contained), even in the eastern markets, than is the corresponding fresh fruit of near-by origin. Much is also exported to European countries and sold at prices within reach of those who cannot afford to buy their native

fresh fruits. Since it was found that the sunshine and dry air of California make out-door drying on a large scale practicable, the drying of fruit has become a "primary industry" and not simply a means of utilizing a surplus crop. Large orchards are planted specifically for the production of fruit for drying, and very large amounts of capital (aggregating millions of dollars) are invested in drying establishments. It is claimed that the fruit which is to be dried is as carefully chosen and handled with as much care in every way as that which is sold fresh or canned. The fruit is graded so that all the fruit on a drying tray shall be approximately the same size. The freshly cut fruit is placed on trays and the trays placed in large boxes or small houses under which sulphur is burned. This treatment of the fruit with sulphur dioxide (called sulphuring) prevents darkening and fermentation during the subsequent air-drying and, as at present conducted, is said also to protect the fruit from insects. It is also claimed that the sulphured fruit dries more rapidly than the untreated. For these reasons it is feasible to dry larger pieces when the sulphuring process is used.

Whether the sulphuring process shall be permitted, and if so what limit shall be placed upon the amount of sulphur dioxide which the fruit may contain, are questions not yet finally decided by those charged with the administration of the Food and Drugs Act.

After the fruit is sufficiently dried it is piled in houses or placed in boxes or bins, where it goes through a "sweating" process during which it must be frequently turned. When danger of further sweating is past, the fruit is packed in boxes of which one standard size is $6 \times 9 \times 15$ inches holding 25 pounds of the dried fruit. This description applies, with varying details, to the drying of peaches, apricots, nectarines, apples, and pears. Of these peaches and apricots are dried in largest quantity.

Prunes are handled somewhat differently, since they are not cut before drying. As a rule the prunes are dipped for

about a minute in boiling lye to thin and crack the skin, then washed to remove the lye and dried in the sun. To insure a sterile surface they may be dipped after drying into a boiling solution of prune juice, glycerin, or salt.

Raisins are also dried by special processes; and these differ too much according to locality and conditions to permit of a concise general description.

Olives are grown in California both for use as fruit and for oil. In a study of 26 varieties of olives at the University of California it was found that the percentage of oil in the whole fruit varied from 11.23 to 29.34 per cent, the pits constituted from 12.0 to 30.0 per cent of the weight of the fruit. The olives varied in size to such an extent that the number of olives per pound ranged from 36 to 398; usually one pound contains from 100 to 250. The pickling of olives is a troublesome process, often involving much loss. Green olives are more easily pickled, but are much inferior to ripe olives as food. Ripe olives canned in dilute salt solution are being put up to some extent in California. Such a product is obviously of much greater food value than the usual immature olive impregnated with strong brine. The production of olive oil will be considered in Chapter X.

Nut growing in California. Almonds and English walnuts are the nuts chiefly grown. The crop varies much from year to year, especially in the case of almonds, but is estimated at about 5,000,000 pounds of almonds and 16,000,000 pounds of walnuts per year.

Almonds are gathered soon after the hulls burst and before the shells become discolored. Hulls are removed by special machinery. The nuts are then dried in the sun, after which they are generally exposed to fumes of burning sulphur in order to insure the light color of shell which the market demands. It is claimed that if the shell has been properly dried, the sulphur dioxide does not penetrate it sufficiently to affect the kernel.

Walnuts are dried and passed over a revolving grader having

a wire screen of one inch mesh; those that fall through are graded as seconds. The shells are commonly bleached either by sulphur dioxide, hypochlorite, or chlorine.

Composition of Fruits and Nuts

The average composition of fruits (fresh, dried, and preserved), as found in the American markets, and of such kinds of nuts as are of commercial importance, is shown in the following table, based chiefly on data compiled by Atwater and Bryant.

TABLE 43. AVERAGE COMPOSITION OF FRUITS AND NUTS

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
FRUITS, BERRIES, ETC., FRESH									
Apples:									
Edible portion . .	29	—	84.6	.4	.5	14.2	(7)1.2	.3	285
As purchased . .	—	25.0	63.3	.3	.3	10.8	—	.3	214
Apricots:									
Edible portion . .	11	—	85.0	1.0	—	13.4	—	.5	263
As purchased . .	—	6.0	79.9	1.0	—	12.6	—	.5	247
Bananas:									
Edible portion . .	6	—	75.3	1.3	.6	22.0	(1)1.0	.8	447
As purchased . .	—	35.0	48.9	.8	.4	14.3	—	.6	290
Blackberries	9	—	86.3	1.3	1.0	10.9	(1)2.5	.5	262
Cherries:									
Edible portion . .	16	—	80.9	1.0	.8	16.7	(1) .2	.6	354
As purchased . .	—	5.0	76.8	.9	.8	15.9	—	.6	337
Cranberries	3	—	88.9	.4	.6	9.9	(2)1.5	.2	212
Currants	1	—	85.0	1.5	—	12.8	—	.7	259
Figs, fresh	28	—	79.1	1.5	—	18.8	—	.6	368
Grapes:									
Edible portion . .	5	—	77.4	1.3	1.6	19.2	(1)4.3	.5	437
As purchased . . .	—	25.0	58.0	1.0	1.2	14.4	—	.4	328

TABLE 43. AVERAGE COMPOSITION OF FRUITS AND NUTS—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
FRUITS, BERRIES, ETC., FRESH									
Huckleberries, edible portion	1	—	81.9	.6	.6	16.6	—	.3	336
Lemons:									
Edible portion . .	4	—	89.3	1.0	.7	8.5	(2)1.1	.5	201
As purchased . .	—	30.0	62.5	.7	.5	5.9	—	.4	140
Lemon juice . . .	22	—	—	—	—	9.8	—	—	178
Muskmelons:									
Edible portion . .	1	—	89.5	.6	—	9.3	2.1	.6	180
As purchased . . .	1	50.0	44.8	.3	—	4.6	—	.3	90
Nectarines:									
Edible portion . .	1	—	82.9	.6	—	15.9	—	.6	299
As purchased . . .	1	6.6	77.4	.6	—	14.8	—	.6	280
Oranges:									
Edible portion . .	23	—	86.9	.8	.2	11.6	—	.5	233
As purchased . . .	—	27.0	63.4	.6	.1	8.5	—	.4	169
Peaches:									
Edible portion . .	2	—	89.4	.7	.1	9.4	(1)3.6	.4	188
As purchased . . .	2	18.0	73.3	.5	.1	7.7	—	.3	153
Pears:									
Edible portion . .	2	—	84.4	.6	.5	14.1	(1)2.7	.4	288
As purchased . . .	—	10.0	76.0	.5	.4	12.7	—	.4	245
Persimmons, edible portion	1	—	66.1	.8	.7	31.5	1.8	.9	615
Pineapple, edible portion	1	—	89.3	.4	.3	9.7	.4	.3	196
Plums:									
Edible portion . .	3	—	78.4	1.0	—	20.1	—	.5	383
As purchased . . .	—	5.0	74.5	.9	—	19.1	—	.5	363
Pomegranates, edible portion	2	—	76.8	1.5	1.6	19.5	2.7	.6	447
Prunes:									
Edible portion . .	24	—	79.6	.9	—	18.9	—	.6	359
As purchased . . .	20	5.8	75.6	.7	—	17.4	—	.5	328

TABLE 43. AVERAGE COMPOSITION OF FRUITS AND NUTS—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
FRUITS, BERRIES, ETC., FRESH									
Raspberries, red	1	—	85.8	1.0	—	12.6	2.9	.6	247
Raspberries, black	3	—	84.1	1.7	1.0	12.6	—	.6	300
Strawberries :									
Edible portion	22	—	90.4	1.0	.6	7.4	(19)1.4	.6	177
As purchased	—	5.0	85.9	.9	.6	7.0	—	.6	168
Watermelons :									
Edible portion	2	—	92.4	.4	.2	6.7	—	.3	136
As purchased	—	59.4	37.5	.2	.1	2.7	—	.1	57
FRUITS, ETC., DRIED									
Apples	3	—	28.1	1.6	2.2	66.1	—	2.0	1318
Apricots	2	—	29.4	4.7	1.0	62.5	—	2.4	1260
Citron	2	—	19.0	1.5	1.5	78.1	—	.9	1487
Currants, Zante	4	—	17.2	2.4	1.7	74.2	—	4.5	1459
Dates :									
Edible portion	2	—	15.4	2.1	2.8	78.4	—	1.3	1575
As purchased	—	10.0	13.8	1.9	2.5	70.6	—	1.2	1416
Figs	3	—	18.8	4.3	.3	74.2	—	2.4	1437
Prunes :									
Edible portion	15	—	22.3	2.1	—	73.3	—	2.3	1368
As purchased	—	15.0	19.0	1.8	—	62.2	—	2.0	1160
Raisins :									
Edible portion	3	—	14.6	2.6	3.3	76.1	—	3.4	1562
As purchased	—	10.0	13.1	2.3	3.0	68.5	—	3.1	1407
Raspberries	1	—	8.1	7.3	1.8	80.2	—	2.6	1662
FRUITS, ETC., CANNED; AND JELLIES, PRESERVES, ETC.									
Apples, crab, as purchased	1	—	42.4	.3	2.4	54.4	—	.5	1090
Apple sauce, as purchased	1	—	61.1	.2	.8	37.2	—	.7	711

TABLE 43. AVERAGE COMPOSITION OF FRUITS AND NUTS—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
FRUITS, ETC., CANNED; AND JELLIES, PRESERVES, ETC.									
Apricots, as purchased	1	—	81.4	.9	—	17.3	—	.4	330
Apricot sauce, as purchased	1	—	45.2	1.9	1.3	48.8	—	2.8	973
Blackberries, as purchased	1	—	40.0	.8	2.1	56.4	—	.7	1124
Blueberries, canned	3	—	85.6	.6	.6	12.8	—	.4	268
Cherries, as purchased	1	—	77.2	1.1	.1	21.1	—	.5	407
Cherry jelly:									
1st quality, as purchased	1	—	21.0	1.1	—	77.2	—	.7	1421
2d quality, as purchased	1	—	38.4	1.2	—	59.8	—	.6	1107
Figs, stewed, as purchased	1	—	56.5	1.2	.3	40.9	—	1.1	776
Grape butter, as purchased	1	—	36.7	1.2	.1	58.5	—	3.5	1087
Marmalade (orange peel), as purchased	1	—	14.5	.6	.1	84.5	—	.3	1548
Peaches, as purchased	3	—	88.1	.7	.1	10.8	—	.3	213
Pears, as purchased	4	—	81.1	.3	.3	18.0	—	.3	344
Pineapples, as purchased	1	—	61.8	.4	.7	36.4	—	.7	696
Prune sauce, as purchased	1	—	76.6	.5	.1	22.3	—	.5	417
Strawberries, stewed, as purchased	1	—	74.8	.7	—	24.0	—	.5	448
Tomato preserves, as purchased	1	—	40.9	.7	.1	57.6	—	.7	1062
NUTS									
Almonds:									
Edible portion	11	—	4.8	21.0	54.9	17.3	2.0	2.0	2940
As purchased	—	45.0	2.7	11.5	30.2	9.5	—	1.1	1615

TABLE 43. AVERAGE COMPOSITION OF FRUITS AND NUTS—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
NUTS									
Beechnuts:									
Edible portion . .	1	—	4.0	21.9	57.4	13.2	—	3.5	2980
As purchased . .	1	40.8	2.3	13.0	34.0	7.8	—	2.1	1766
Brazil nuts (<i>Bertholletia excelsa</i>):									
Edible portion . .	1	—	5.3	17.0	66.8	7.0	—	3.9	3162
As purchased . .	1	49.6	2.6	8.6	33.7	3.5	—	2.0	1595
Butternuts (<i>Juglans cinerea</i>):									
Edible portion . .	1	—	4.4	27.9	61.2	3.5	—	2.9	3068
As purchased . .	1	86.4	.6	3.8	8.3	.5	—	.4	417
Chestnuts, fresh:									
Edible portion . .	9	—	45.0	6.2	5.4	42.1	1.8	1.3	1097
As purchased . .	9	16.0	37.8	5.2	4.5	35.4	—	1.1	920
Chestnuts, dried:									
Edible portion . .	8	—	5.9	10.7	7.0	74.2	2.7	2.2	1828
As purchased . .	8	24.0	4.5	8.1	5.3	56.4	—	1.7	1386
Coconuts:									
Edible portion . .	1	—	14.1	5.7	50.6	27.9	—	1.7	2675
As purchased . .	1	48.8	7.2	2.9	25.9	14.3	—	.9	1369
Coconut without milk, as purchased . .	1	37.3	8.9	3.6	31.7	17.5	—	1.0	1677
Coconut milk, as purchased . .	1	—	92.7	.4	1.5	4.6	—	.8	152
Coconut, prepared	2	—	3.5	6.3	57.4	31.5	—	1.3	3028
Filberts:									
Edible portion . .	1	—	3.7	15.6	65.3	13.0	—	2.4	3185
As purchased . .	1	52.1	1.8	7.5	31.3	6.2	—	1.1	1526
Hickory nuts:									
Edible portion . .	1	—	3.7	15.4	67.4	11.4	—	2.1	3238
As purchased . .	1	62.2	1.4	5.8	25.5	4.3	—	.8	1224
Lichi nuts:									
Edible portion . .	1	—	17.9	2.9	.2	77.5	—	1.5	1466
As purchased . .	1	41.6	10.5	1.7	.1	45.2	—	.9	855

TABLE 43. AVERAGE COMPOSITION OF FRUITS AND NUTS - Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
NUTS									
Peanuts:									
Edible portion . .	4	—	9.2	25.8	38.6	24.4	2.5	2.0	2490
As purchased . . .	—	24.5	6.9	19.5	29.1	18.5	—	1.5	1858
Peanut butter, as purchased	2	—	2.1	29.3	46.5	17.1	—	5.0	2741
Pecans, unpolished:									
Edible portion . .	1	—	2.7	9.6	70.5	15.3	—	1.9	3330
As purchased . . .	1	46.3	1.5	5.1	37.9	8.2	—	1.0	1788
Pine nuts:									
Pignolias, edible portion	1	—	6.4	33.9	49.4	6.9	—	3.4	2757
Piniones (<i>Pinus monophylla</i>):									
Edible portion . .	1	—	3.8	6.5	60.7	26.2	—	2.8	3060
As purchased . . .	1	41.7	2.2	3.8	35.4	15.3	—	1.6	1792
Piñon (<i>Pinus edulis</i>):									
Edible portion . .	1	—	3.4	14.6	61.9	17.3	—	2.8	3105
As purchased . . .	1	40.6	2.0	8.7	36.8	10.2	—	1.7	1905
Sabine pine nut (<i>Pinus sabiniana</i>):									
Edible portion . .	1	—	5.1	28.1	53.7	8.4	—	4.7	2855
As purchased . . .	1	77.0	1.2	6.5	12.3	1.9	—	1.1	655
Pistachios:									
First quality, shelled, edible portion . . .	1	—	4.2	22.3	54.0	16.3	—	3.2	2905
Second quality, shelled, edible portion	1	—	4.3	22.8	54.9	14.9	—	3.0	2928
Walnuts, California:									
Edible portion . .	1	—	2.5	18.4	64.4	13.0	1.4	1.7	3200
As purchased . . .	1	73.1	.7	4.0	17.3	3.5	—	.5	859

TABLE 43. AVERAGE COMPOSITION OF FRUITS AND NUTS—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
NUTS									
Walnuts, California, black:									
Edible portion . . .	2	—	2.5	27.6	56.3	11.7	1.7	1.9	3012
As purchased . . .	—	74.1	.6	7.2	14.6	3.0	—	.5	781
Walnuts, California, soft shell:									
Edible portion . . .	4	—	2.5	16.6	63.4	16.1	2.6	1.4	3182
As purchased . . .	—	58.1	1.0	6.9	26.6	6.8	—	.6	1335

Chemical changes in the ripening of fruits. During ripening many fruits undergo distinct changes in composition, and these changes may continue after the gathering of the fruit. In general the ripening involves a decrease in acid and starch with an increase in sugar content. Oxidation processes also go on in the fruit with the development of "ethereal" substances (probably esters) and evolution of carbon dioxide.

Quite elaborate investigations of the changes which fruits undergo during ripening have been carried on by Bigelow and by Langworthy and their associates, in the United States Department of Agriculture. With winter apples, for example, it was found that the starch content reaches its maximum about midsummer and then decreases and finally disappears almost entirely. This change is strikingly shown by treating the cut surface of specimen apples with iodine, which colors starch deep blue. The decreasing depth of color with decreasing starch



FIG. 26. — Showing decrease of starch with ripening of apple. (See explanation in text, pp. 341, 343.)

content as the apple approaches maturity is readily seen in Fig. 26. The acid content of the apples was found to decrease from early summer until maturity, while the sugar content increases.

In bananas also there is a marked conversion of starch into sugar as the fruit ripens.

The peach, on the other hand, contains no appreciable amount of starch at any time, but shows a steady increase in sugar content as it approaches maturity.

In fruits generally there is an apparent decrease of the pectin substances as the fruit ripens, as indicated by the fact that under-ripe fruit yields firmer jelly.

Digestibility and Nutritive Value of Fruits and Nuts

In dietary studies and digestion experiments fruits and nuts are often considered together, largely because a large proportion of the accurately recorded data has been gathered by Jaffe in connection with his investigations upon California fruitarians whose diet is one of fruits and nuts. In 28 digestion experiments with 2 men and 1 woman upon fruit and nut diet the average coefficients of digestibility were: for protein, 90 per cent; for fat, 85 per cent; for carbohydrate, 95 per cent.

Apparently the fruit and nut diet was as readily and almost as completely digested as would be expected of ordinary mixed diet.

The fact that consistent fruitarians, both adults and children, maintain a well-nourished condition on diets of fruits and nuts which are of moderate total food value and low protein content is strong evidence that the nutrients of the fruits and nuts must be well digested and also efficiently utilized in metabolism. This is in harmony both with the belief that man is descended from ancestors whose chief food was fruit and nuts, and with the results of modern investigations of the chemical structure of the nut proteins.

The nut proteins have not been analyzed extensively, but Osborne and his associates report the hydrolysis of two as follows. Excelsin is the principal protein of Brazil nuts, and amandin of almonds.

TABLE 44. PERCENTAGES OF AMINO ACIDS FROM NUT PROTEINS
(OSBORNE)

	AMANDIN (ALMONDS)	EXCELSIN (BRAZIL NUTS)
Glycin	0.51	0.6
Alanin	1.40	2.3
Valin	0.16	1.5
Leucin	4.45	8.7
Phenylalanin	2.53	3.5
Tyrosin	1.12	3.1
Prolin	2.44	3.6
Oxyprolin		?
Aspartic acid	5.42	3.8
Glutamic acid	23.14	12.9
Arginin	11.85	16.1
Lysin	0.70	1.6
Histidin	1.58	2.5
Tryptophan	present	present
Ammonia	3.70	1.8
Summation	59.00	62.0

Further and more conclusive evidence of the high food value of at least one of the nut proteins is found in the recent experiments of Osborne and Mendel in which rats are fed on known mixtures of isolated food substances. Excelsin of the Brazil nut has been shown in these experiments to be one of the proteins which is in itself ample for all the requirements of protein metabolism in normal nutrition. Not only does excelsin as a sole protein food maintain protein equilibrium, but young animals make a normal growth and development upon diets in which excelsin is the only nitrogenous food.

It is plain that fruits and nuts are to be regarded as staple

articles of food and by no means as simply relishes or accessories. By a consideration of composition and cost it will also be found that many of the fruits and nuts are quite economical as compared with many other staple foods.

Place of Nuts in the Diet

From the tables of composition given above it is apparent that nuts vary considerably in composition, some (as chestnuts) being starchy, others (as coconuts and walnuts) being especially rich in fat, while many (as almonds, Brazil nuts, butternuts, and peanuts) are rich in both protein and fat.

Nuts in general, being rich in both protein and fat, are comparable with meats as food and may be used interchangeably with meat in the diet; in fact they are being so used to an increasing extent. With the constant tendency toward higher cost of meat, which must be anticipated for reasons already explained (page 214), and with growing knowledge of nut culture, we may look for a much larger use of nuts as "meat substitutes"¹ in the future. Even at present prices the economy of nuts both as sources of energy and of protein will doubtless be surprising to many who have not previously compared the composition and cost of typical articles of these groups.

Thus 10 cents spent for beefsteak at 25 cents per pound will buy about 400 Calories with about 30 grams of protein, while the same amount spent for shelled almonds at 50 cents a pound will buy about 600 Calories with about 25 grams of protein; if spent for peanuts at 10 cents a pound it would buy about 1800 Calories with 90 grams of protein; or spent for peanut butter at 33 cents a pound (25 cents for a jar containing 12 ounces net) the same amount would buy 750 Calories with 35 grams of protein.

¹ To speak of nuts as "meat substitute" is natural under present conditions and reflects the prominence which has been given to meat and the casual way in which nuts have been regarded for some generations. Looking at the matter in evolutionary perspective it might be more logical to speak of meats as "nut substitute" instead.

Thus not only the roasted peanuts but the best grade of almonds or of carefully prepared peanut butter is plainly a much more economical food than the steak, even when the latter is not charged with the cost of preparing it for the table.

The reader may extend the comparison to other nuts at the prices found in the local markets.

The Place of Fruits and Vegetables in the Diet

Fruits and vegetables vary too much in their chemical composition and other properties to permit many broad generalizations in regard to their place in the diet.

Potatoes, sweet potatoes, and bananas are easily comparable with each other, but difficult to compare in many respects with celery, tomatoes, or grapefruit.

Differences in food value are due largely to the wide variations in water content, but also to the different quantitative proportions which the nutrients bear to each other, and in some instances to the presence of characteristic substances.

Considered as sources of energy potatoes and dry beans and peas are at ordinary prices about as economical as grain products and much more economical than the meats; while the dried fruits are comparable in economy as fuel with milk, butter, and the fatter and cheaper kinds of meat. Even those fruits and green vegetables which are eaten for flavor with little thought of food value and which are often thought of as luxuries because of their high water content will often be found to furnish energy at no greater cost than many of the familiar cuts of meat when account is taken of the extent to which the fat of the meat is usually rejected or lost in cooking or at the table.

That the dry legumes are both absolutely and relatively rich in protein is a fact so well recognized as not to require elaboration here. Less generally realized is the fact that while the green vegetables contain too much water to show high absolute values or percentages by weight of protein, yet they

show as much or more of the total food value in the form of protein as is customary or desirable in ordinary diets. In fruits, on the other hand, the relative proportion as well as the absolute amount of protein is usually low. The proportion of energy furnished by protein, as well as numerous other data, may be found for all the common articles of food in the table of 100-Calorie portions at the back of this book (Appendix E).

Taking the fruits and vegetables as a whole, while often more economical as sources of energy and protein than is generally considered, yet they are probably even more significant for their ash constituents than for the organic nutrients which they contain.

The percentages of individual ash constituents in the edible portion of each of the important fruits and vegetables (in so far as trustworthy analyses are available) are given in the accompanying table.

TABLE 45. ASH CONSTITUENTS OF FRUITS AND VEGETABLES IN PERCENTAGE OF THE EDIBLE PORTION
(Compiled from various sources)

Food	CaO	MgO	K ₂ O	Na ₂ O	P ₂ O ₅	Cl	S	Fe
Apples	.014	.014	.15	.02	.03	.004	.005	.0003
Apricots	.018	.018	.28	.06	.06	.003	.013	
Asparagus	.04	.02	.20	.01	.09	.04	.04	.0010
Bananas	.01	.04	.50	.02	.055	.20	.013	.0006
Beans, dried	.22	.25	1.40	.26	1.14	.03	.22	.0070
lima, dried	.10	.31	2.1	.33	.77	.025	.16	.0070
lima, fresh	.04	.11	.7	.12	.27	.009	.06	.0025
string	.075	.043	.28	.03	.12	.018	.04	.0016
Beets	.03	.033	.45	.10	.09	.04	.015	.0006
Blackberries	.08	.035	.20		.08		.01	
Blueberries	.045	.015	.05		.02			
Breadfruit	.12	.01	.28	.04	.16	.10		
Cabbage	.068	.026	.45	.05	.09	.03	.07	.0011
Carrots	.077	.034	.35	.13	.10	.036	.022	.0008
Cauliflower	.17	.02	.27	.10	.14	.05	.085	

TABLE 45. ASH CONSTITUENTS OF FRUITS AND VEGETABLES IN PERCENTAGE OF THE EDIBLE PORTION—Continued

Food	CaO	MgO	K ₂ O	Na ₂ O	P ₂ O ₅	Cl	S	Fe
Celery	.10	.04	.37	.11	.10	.17	.025	.0005
Chard	.22	.11	.46	.12	.09	.04	.12	
Cherries	.03	.027	.26	.03	.07	.01	.01	.0005
Cherry juice . .	.025	.02	.15	.02	.03	.004	.006	
Chicory	.05	.03	.27	.11	.09	.06		
Chives	.20	.05	.33	.04	.20	.04		
Citron	.17	.03	.25	.02	.08	.01	.02	
Coconut pulp . .	.09	.10	.77	.10	.38	.25	.03	
Corn, sweet, dried	.03	.20	.5	.2	.8	.05	.16	.0029
sweet, fresh . .	.008	.055	.137	.05	.22	.014	.044	.0008
Cranberries . . .	.024	.011	.09	.013	.03	.005	.008	.0006
Cucumbers	.022	.015	.17	.015	.08	.03	.022	
Currants, fresh . .	.05	.04	.25	.02	.10	.01	.01	.0005
Zante	.14	.08	1.0	.1	.3	.06	.06	
Currant juice . .	.03	.02	.2		.05		.005	
Dandelion greens .								.0027
Dates	.10	.13			.12	.32	.066	.003
Endive	.14	.02	.45	.15	.10		.03	
Figs, fresh	.074	.036	.365	.016	.082	.014		.0008
dried	.299	.145	1.478	.064	.332	.056	.056	.0032
Gooseberries . . .	.05	.02	.21	.03	.65	.01		
Grapefruit	.03	.02	.17		.04	.01	.01	.0004
Grapes	.024	.014	.25	.03	.12	.01	.024	.0013
Grape juice (and must)	.021	.016	.20	.01	.04	.01	.012	
Guava	.02	.013	.46		.07	.05		
Horseradish . . .	.13	.065	.56	.08	.1	.02	.18	
Huckleberries . .	.035	.025			.07	.02	.013	.0011
Leeks	.08	.02	.24	.11	.15	.03	.08	
Lemons	.05	.01	.21	.01	.02	.01	.012	.0006
Lemon juice . . .	.033	.01	.17	.01	.025	.01	.007	
Lemon, sweet . .	.04	.01	.53		.10	.01		
Lentils	.15	.17	1.05	.08	1.0	.05	.28	.0086
Lettuce	.05	.01	.42	.04	.09	.06	.014	.001
Limes	.08	.02	.42		.08	.04	.003	
Mamey	.02	.02	.42		.06	.14		
Mango	.03	.01	.28		.04	.02	.013	
Muskmelons . . .	.024	.020	.283	.082	.035	.041	.014	.0003

TABLE 45. ASH CONSTITUENTS OF FRUITS AND VEGETABLES IN PERCENTAGE OF THE EDIBLE PORTION—Continued

Food	CaO	MgO	K ₂ O	Na ₂ O	P ₂ O ₅	Cl	S	Fe
Olives	.17	.01	1.8	.17	.03	.01	.025	.0029
Onions	.06	.03	.23	.02	.12	.02	.06	.0005
Oranges	.06	.02	.22	.01	.05	.01	.013	.0003
Orange juice	.05	.02	.22	.01	.03	.01	.008	
Paprika	.32	.27	2.5	.24	.78	.15	.015	
Parsnips	.09	.07	.70	.01	.19	.03	.057	
Peaches	.01	.02	.25	.02	.047	.01	.01	.0003
Pears	.021	.019	.16	.03	.06	.003	.012	.0003
Peas, dried	.14	.24	1.06	.16	.91	.04	.23	.0056
fresh	.04	.07	.30	.04	.26	.01	.06	.0016
cowpeas, dried	.18	.21	1.01	.40	1.00	.02		
Persimmons	.03	.015	.35	.02	.05	.01	.005	
Pineapple	.02	.02	.38	.02	.06	.05	.009	.0005
juice					.02	.05	.007	
Plums	.025	.02	.25	.03	.055	.01	.007	.0005
Potatoes	.016	.036	.53	.025	.140	.03	.03	.0013
sweet	.025	.02	.47	.06	.09	.12	.02	.0005
Prunes, dried	.06	.08	1.2	.1	.25	.01	.03	.0029
Pumpkins	.03	.015	.08	.08	.11	.01	.02	
Quince juice			.18		.035			
Radishes	.05	.02	.17	.11	.09	.05	.05	.0006
Raisins	.08	.15	1.0	.19	.29	.07	.06	.005
Raspberries	.07	.04	.21		.12		.017	
Raspberry juice	.03	.03	.17	.01	.03	.01	.009	
Rhubarb	.06	.02	.39	.03	.07	.035	.013	
Rutabagas	.1	.03	.48	.11	.13	.06	.08	
Salsify					.12		.04	
Sapota	.04	.02	.22		.02	.09	.01	
Spinach	.09	.08	.94	.20	.13	.02	.041	.0032
Squash	.02	.01	.17	.002	.05	.02	.014	.0008
Strawberries	.05	.03	.18	.07	.064	.01		.0009
Tamarinds	.01	.03			.15	.01	.01	
Tomatoes	.020	.017	.35	.01	.059	.03	.02	.0004
Tomato juice	.01	.017	.35	.02	.034	.05	.012	
Turnips	.089	.028	.40	.08	.117	.04	.07	.0005
Turnip tops	.48	.05	.37	.11	.11	.17	.07	
Water cress	.26	.05			.07			
Watermelon	.02	.02	.09	.01	.02	.01	.007	

Comparison of one food with another from data given in such a table as this may give misleading impressions unless it be constantly kept in mind that some of the materials are quite dry while others are perhaps nine tenths water and only one tenth dry matter and further that the dry matter is of higher food value in some cases than in others.

For this reason the comparison of ash constituents on the basis of the 100-Calorie portion rather than of percentage by weight may be found more satisfactory. The table of 100-Calorie portions given at the back of this book shows the amount of calcium, phosphorus, and iron. Taking from that table the weight in grams of the 100-Calorie portion of any food material, the weight of any other ash constituent may readily be calculated from the percentage as shown in the table here given.¹

As sources of iron the green vegetables are perhaps the most important of all our foods, while other vegetables and many fruits are also very important sources of food-iron. This subject can be but briefly mentioned here as it has been quite fully discussed elsewhere.²

Since there has been among dietitians of the older school a tendency to regard meats as the main source of food-iron, a brief comparison of meats with vegetables and fruits from this standpoint may be desirable.

In the average of 15 American dietary studies the cost of meat and fish was 35 per cent of the total expenditure for food and the cost of vegetables and fruits was 18 per cent; the former furnished 35 per cent of the total iron and the latter 27 per cent. Thus *in proportion to cost* the fruits and vegetables furnished much more iron than the meats and fish.

The question, however, is one of kind as well as amount. The iron in meat is chiefly due to the blood remaining in the

¹ A table showing full ash analyses calculated to the 100-Calorie portion is given in the Appendix to *Chemistry of Food and Nutrition*.

² *Chemistry of Food and Nutrition*, Chapter IX.

small blood vessels with which the meat is permeated. The iron compounds of blood do not yield readily to the digestive ferments as do those of vegetables and fruits, so that the iron of the latter is better absorbed and becomes more completely available for nutrition than the iron of the meats.

Moreover the use of too much meat (especially by persons of sedentary habits or indoor occupation) tends toward excessive intestinal putrefaction with resulting absorption of putrefactive products which are detrimental to the red blood cells and probably in other ways interfere with the economy of iron in the body. Fruits, and vegetables, on the other hand, have the opposite property and their use in liberal quantities tends to prevent or correct intestinal putrefaction, both by stimulating peristalsis and by furnishing a medium less favorable to the activities of the putrefactive bacteria. Herter showed that in a large proportion of anæmic people the anæmia is closely correlated with excessive intestinal putrefaction and that improved condition of the blood followed quickly upon the establishment of a better intestinal hygiene. Interesting in this connection is Herter's observation that anæmia is much more common among the carnivorous than among the herbivorous animals, and that the feces of carnivora are much more likely to show putrefactive bacteria of the actively injurious types such as *B. welchii* (*B. aërogenes capsulatus*).

The mild laxative tendency of many fruits and vegetables depends in part upon the fact that they furnish to the digestive tract a sufficiently bulky residue (largely of cellulose and related substances) to stimulate mechanically and render effective the peristaltic action, and in part upon the occurrence in many fruits and some vegetables of substances which, aside from the mechanical considerations, exert a mild laxative effect. Sometimes the raw fruit is found to be more laxative than the same fruit when thoroughly cooked. In some cases the astringent substances in the skin may counteract the laxative effect of the raw flesh of the

fruit; thus some persons find the flesh of raw (or even stewed) apples too laxative, but experience no inconvenience when the skin of the apple is eaten with the flesh and the whole is thoroughly chewed.

Another important effect of eating fruit is the introduction of an acid substance into the digestive tract which later yields an alkaline or basic substance in the blood and tissues. This acidity of fruits is largely due, not to free acids, but to acid potassium salts, of which the acid potassium tartrate (cream of tartar) of grapes may serve as an example.

It will be noted that in all the fruits and vegetables the percentage of potassium (expressed as K_2O in the table) is high either absolutely or as compared with the other ash constituents in the same food. Like the calcium, magnesium, and sodium, the potassium exists in the foods in part as neutral inorganic salts. In many cases, however, it exists to an even larger extent in combination with organic acids or other organic matter. When the food is burned, either in the air or in the body, the organic radicles are oxidized to carbon dioxide and water and so much of the potassium as was combined with organic matter remains as a carbonate. The presence of potassium carbonate (potash) in wood ashes is familiar to every one and accounts for the fact that the wood ashes are alkaline or basic. Similarly those parts of plants which are used for food in the form of fruits and vegetables yield, on burning, a basic or alkaline ash due to the fact that the base-forming elements predominate over the acid-forming elements in these foods, chiefly because of the presence of the organic potassium compounds just mentioned. The surplus of base-forming elements which remains as carbonate and makes the ash distinctly alkaline when the food is burned at a high temperature in the air will, when the material is oxidized in the body, remain as bicarbonate, which is a practically neutral substance, yet capable of neutralizing acids such as the sulphuric acid produced in the protein

metabolism. Thus the predominance of base-forming elements among the ash constituents of fruits and vegetables is of great value to the body in facilitating the maintenance of the normal neutrality of the blood and tissues.

To obtain a quantitative expression of the extent to which either the acid-forming or the base-forming elements predominate, calculate from the amounts of acid-forming elements the volume of normal acid which these elements could yield, and similarly the volume of normal alkali from the base-forming elements. The excess of acid or alkali, as the case may be, expressed in cubic centimeters of normal solution, affords a convenient expression of the acid-forming or base-forming tendency of the food, or as sometimes called its "potential acidity" or "potential alkalinity."

Table 46 shows the potential alkalinity or predominance of base-forming elements — expressed in the units already explained — (1) in each 100 grams of *edible portion* of the fruit or vegetable, (2) in the 100-Calorie portion, (3) in one pound of the material *as purchased*.

TABLE 46. "POTENTIAL ALKALINITY" OR "EXCESS OF BASE-FORMING ELEMENTS" IN VARIOUS FRUITS AND VEGETABLES

FOOD MATERIAL	PER 100 GM. EDIBLE PORTION	PER 100 CAL.	PER POUND AS PURCHASED
Apples	3.7	6.	12.8
Apricots	6.8	10.9	26.9
Asparagus	.8	3.6	3.6
Bananas	5.6	5.6	16.2
Beans, dried	18.	5.	78.3
lima, dried	41.6	12.	190.3
fresh	14.	11.6	29.
string, fresh	5.4	12.9	22.7
Beet, fresh	10.9	23.6	39.4
Cabbage	6.	18.	21.8
Carrots	10.8	23.9	37.8
Cauliflower	5.3	17.5	24.3
Celery	7.8	42.1	28.6

TABLE 46. "POTENTIAL ALKALINITY" OR "EXCESS OF BASE-FORMING ELEMENTS" IN VARIOUS FRUITS AND VEGETABLES—Continued

FOOD MATERIAL	PER 100 GM EDIBLE PORTION	PER 100 CAL.	PER POUND AS PURCHASED
Chard	15.8	41.1	69.7
Cherry juice	4.4		
Citron	9.8	3.	44.6
Cranberries	1.8	3.8	8.6
Cucumbers, fresh	7.9	45.5	30.9
Dates	11.0	3.2	45.3
Grapes	2.7	2.8	9.2
Grape juice	3.9	4.	18.1
Lemons	5.5	12.3	27.4
Lemon juice	4.1	10.7	19.0
Lettuce	7.4	38.7	27.9
Mushrooms	4.	9.	1.8
Muskmelons	7.5	18.8	16.6
Olives	47.2	18.9	188.1
Onions	1.5	3.1	6.2
Oranges	5.6	10.9	18.4
Orange juice	4.5	14.3	28.
Parsnips	11.9	18.1	42.7
Peas, fresh	1.3	1.3	3.3
dried	5.	1.4	22.6
Peaches, fresh	5.	12.2	15.6
Pears, fresh	3.6	5.6	14.3
Pineapple, fresh	6.8	15.7	30.8
Plums	6.2	7.3	26.5
Potatoes	7.	8.6	26.
Potatoes, sweet	6.7	5.4	24.1
Prunes, dried	25.	8.	92.8
Pumpkins	1.5	5.7	3.4
Radishes	2.9	9.8	8.9
Raisins	23.7	6.9	97.
Raspberry juice	4.9		
Rhubarb	8.6	37.4	23.6
Rutabagas	8.5	29.8	
Spinach	27.	113.	122.
Tomato juice	6.2		28.1
Tomatoes	5.6	24.5	25.5
Turnips	2.7	6.8	25.
Watermelon	2.7	8.9	5.1

From what has been said it is to be expected that the eating of vegetables and fruits will diminish the acidity of the urine. This has been tested by Blatherwick, who finds in all of his experiments with vegetables and most of those with fruits that the urinary acidity is diminished as expected, showing that the potential alkalinity had actually been utilized in the neutralization of acid in the body; but with some fruits there may be an incomplete oxidation of the fruit-acid in the system and so the potential alkalinity may not be fully realized.

It should be clearly understood that an excess of base-forming elements in the food is not in any sense objectionable, since the oxidation processes in the body are constantly yielding such large quantities of carbonic acid that any surplus of base-forming elements goes to form bicarbonates, which do not disturb the neutrality, but rather act as a reserve material for its maintenance.

The balance of acids and bases per 100-Calorie portion of all the common articles of food is shown in the table at the back of this book. In planning dietaries by the convenient method of building them up from 100-Calorie portions it will be easy with the data there given to find the "balance of acids and bases" for the dietary as a whole. In the writer's opinion it is distinctly preferable that the balance fall on the basic side. If an excess of acid-forming elements be permitted, it would seem that the excess should not exceed 25 units (the equivalent of 25 cc. of normal acid) per man per day, which is about the quantity neutralizable by the amount of ammonia to be expected in a day's urine under favorable conditions.

Since meats and eggs show a distinct excess of the acid-forming elements, while in vegetables and fruits the base-forming elements predominate, it follows that the greater the amount of meat, fish, and eggs eaten the more important is it that fruits and vegetables be also used liberally. A 100-Calorie portion of potato furnishes just about the amount of base to neutralize

the acid arising from the metabolism of a 100-Calorie portion of steak. To serve a 200-Calorie portion of steak with only a 100-Calorie portion of potato is out of proportion. The grain products have an excess of acid-forming elements, not large enough to be objectionable when the diet is otherwise well balanced, but which may result in the diet as a whole becoming too strongly acid-forming if grain products are allowed to take the place of vegetables. Rice and potatoes are sometimes considered interchangeable, but from this standpoint cannot be so considered. When rice instead of potato is served with meat, not only is the excess acid from the meat left unprovided for, but more acid is added by the rice. Hence, even though the rice furnishes as much energy and protein, it cannot properly be regarded as of fully equal food value with the potato which it displaces.

In order to avoid too great an excess of acid in cases in which no dietary calculations are made, it is well to allow at least as much money for the purchase of vegetables, fruits, and milk (in which base-forming elements predominate) as for the purchase of meats, fish, and eggs (all of which are distinctly acid-forming).

While not yet fully understood, the vitamine content seems likely to prove a factor of some importance in the rôle of fruits and vegetables in the diet. The "antiscorbutic property" of these foods is well recognized. The evidence has seemed to favor the view that this property is chiefly due to the predominance of base-forming ash constituents,¹ but recent work indicates that vitamines must also be taken into account in this connection.

Some of the advantages of fruits and vegetables as food cannot be expressed in quantitative terms, but even the factors which can be so expressed show that these foods, even when bought, as is usual, with reference to flavor rather than food value, are more economical than is generally supposed.

¹ Compare *Chemistry of Food and Nutrition*, pp. 293-294.

Thus the data of 15 American dietary studies supposed to be representative of ordinary food habits in their respective localities show the following average results when the cost of, and returns from, the fruits and vegetables, the vegetables alone, and the potatoes alone, are calculated in percentage of the total food (Table 47).

TABLE 47. ECONOMY OF FRUITS AND VEGETABLES IN THE DIET

IN FIFTEEN AMERICAN DIETARIES	PER CENT OF TOTAL COST	PER CENT OF TOTAL CALORIES	PER CENT OF TOTAL PROTEIN	PER CENT OF TOTAL PHOSPHORUS	PER CENT OF TOTAL IRON
Fruits and Vegetables .	18.7	11.8	10.6	18.7	27.3
Vegetables	11.1	9.0	9.8	18.0	20.6
Potatoes	3.9	5.3	4.2	8.7	13.5

If we take account of the fact that we must purchase phosphorus and iron compounds as well as protein and energy in the food, we see that the money spent for fruits and vegetables yielded its proportionate return in nutritive value if not in Calories and protein. Potatoes, it will be seen, were very economical sources of protein and energy as well as of ash constituents.

In any case the percentages of nutrients give an inadequate expression of the true value of fruits and vegetables as food. In fact the low protein, fat, and carbohydrate content which causes some of the fruits and green vegetables to be regarded merely as luxuries may at times be an actual advantage in enabling one to balance a dietary by adding these foods without either making protein or energy intake excessive or necessitating a restriction of the consumption of foods already in use.

Unquestionably the more general and more liberal use of fruits and vegetables is to be encouraged. Where the cost of food must be strictly limited, the dietary may often be improved by diminishing the expenditures for meats and sweets in order that vegetables and fruits may be used more freely.

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CHAPTER X

EDIBLE FATS AND OILS

EDIBLE fats and oils are separated on a commercial scale from a great variety of food materials: butter from milk; oleo-margarine, lard, and suet from meat fats; corn oil from grain; olive oil from a fruit; peanut (arachis) oil from a legume seed of nut-like character; coconut oil from a true nut; cottonseed oil from the seeds of a plant of still a different family. Of the various food fats of commerce, butter is, in America at least, by far the most prominent, and the butter industry will therefore be treated more fully than the other fat and oil industries.

Butter

The butter reported made in the United States in the census year 1909 amounted to 994,650,610 pounds valued at \$222,861,440 made on farms, and 627,145,865 pounds valued at \$180,174,790 made in factories, or in all 1,621,796,475 pounds of butter valued at \$403,036,230.

Thus in money value of annual product, the butter industry is of similar size to the market milk industry, the egg industry, or the sugar industry.

Since relatively small amounts of butter are imported or exported, the consumption may be taken as approximately equal to the production, and amounts therefore to about 17½ to 18 pounds of butter per capita per year, or three fourths to four fifths of an ounce per person per day.

Butter making was, until about fifty years ago, entirely a household industry. Since then the industry of making butter

in central creameries or butter factories has grown until at present about two fifths of the butter is made in such establishments, and the proportion is constantly increasing. The description which follows relates chiefly to the making of butter in creameries or butter factories.

It is said that the first creamery was built by Alanson Slaughter in Orange County, New York, in 1861, and received the milk of about 375 cows. Less than forty years later, in 1900, a single creamery at St. Albans, Vermont, received the milk (or cream) from more than 30,000 cows, from which was made in one room between 20,000 and 25,000 pounds of butter per day.

A considerable proportion of the creameries or butter factories are owned by associations of farmers and conducted on a co-operative plan. The farmer who sends milk to the creamery is often spoken of as a patron. When the farm is at a distance from the creamery, the farmer often separates the cream and sends it alone to the creamery. Payment either for milk or cream is usually based upon the actual determination of fat content (usually by means of the Babcock test).

In order to simplify this part of the work, it is common to weigh the milk in a large cylindrical can (which remains on the scale) and after weighing each delivery take a sample by means of a Scovell or McKay sampling tube which will accurately represent the milk of the can from top to bottom and will be proportional in quantity to the amount of milk delivered. This sample is poured from the tube into a bottle or jar which contains a preservative and the jar kept closed to prevent evaporation. One jar thus serves for each patron, and the daily samples are composited in the jar for as many days as desired (usually a week, ten days, or two weeks), then tested, and the percentage of fat found in the composite sample is multiplied by the total weight of milk which it represents.

A butter factory makes more pounds of butter than it receives of butter-fat in the milk because the losses of fat are more than

compensated for by the water, curd, and salt of the butter. The excess of butter made over butter-fat received is called the "over-run."

The amount of over-run depends on: (1) the thoroughness of skimming, (2) the completeness of churning, (3) the general losses in the factory, (4) the composition of the butter. It is generally calculated in percentage of the fat received and may usually be expected to average about 10 per cent.

Under good conditions and management, the fat content of the skim-milk should not exceed 0.1 per cent, and in the butter-milk 0.2 per cent as determined by the Babcock test.

Cream may be obtained from milk either by gravity or by centrifugal force. The prevailing method at present is by means of centrifugal separators in which the milk flows continuously into a rotating bowl containing thin metal plates which separate the milk into inclined sheets in which by centrifugal force the heavier part is thrown toward the outer rim¹ and the lighter fat globules are forced toward the center. Thus while the separator is in operation, a continuous stream of cream and another of skimmed milk is obtained from the inner and outer layers respectively of the rotated bowl of milk. In order that the skimmed milk shall not be thrown out of the machine with too great force, the tubes which receive it from the outer portion of the bowl are carried back toward the center of the bowl, where they discharge into the outlet pipe. The size of the skim-milk outlet may be made to bear any desired relation to the size of inlet, size of bowl, and speed of rotation, and thus any desired proportion of the whole milk may be drawn off as skimmed milk while the remainder is forced to the center of the bowl and discharged through the cream outlet. MacKay and Larsen state that for butter-making, a cream containing from 25 per cent up

¹ Suspended solids heavier than the skimmed milk are forced against the outer surface and result in a deposit of "separator slime."

to 50 per cent of fat may be taken according to the preference of the butter-maker.

Pasteurization of milk or cream for use in butter-making is growing in favor. It eliminates not only any pathogenic bacteria which may be present, but most other bacteria as well, and makes it possible to control the ripening of the cream by adding to the pasteurized cream a culture of bacteria which will produce the type of fermentation desired. This enables the trained butter-maker to produce butter of more uniform character and better keeping quality.

Ripening of cream is an acid fermentation, the object of which is to produce a butter of desirable flavor and aroma. Ripened cream also churns more easily and completely than that which has not been ripened.

Different butter-makers use temperatures varying from 60° to 80° F. in ripening cream, the higher temperatures being employed when it is desired to complete the process as rapidly as possible. Ordinarily it is considered that a better type of fermentation is secured at 60° to 70° F. than at a higher temperature. The desired temperature is maintained by keeping the cream, during the ripening process, in a water-jacketed vat.

In the ripening-vat the cream is mixed with (usually) one tenth to one fifth of its volume of "starter," which consists of clean skimmed milk in active lactic acid fermentation induced either by the addition of commercial cultures of lactic acid bacteria or by keeping a good natural milk at about 70° F. until it shows a clean pleasant acid odor and taste, and coagulates to a smooth uniform curd. Before the starter is added to the cream, it is strained or poured back and forth between sterilized cans until the curds which it contains are broken into very small particles; otherwise the lumps of curd may appear as whitish mottles in the finished butter. If necessary, the starter may be strained before mixing with the cream. The cream and starter should be thoroughly stirred together and the stirring

should be repeated at intervals during the ripening process in order that the acid fermentation may predominate uniformly throughout and that the fat globules may have the most favorable conditions for absorbing the desired aroma.

In general the degree of acidity reached by the cream in the ripening process is an indication of the degree of flavor that the butter will have. Some markets require a more highly flavored butter than others.¹

Churning consists in agitating cream in such a way that the fat globules stick together into masses of butter large enough to be separated from the buttermilk.

The churns now in general use in American butter factories, and which are being introduced into Europe, are the "combined churns" which are so arranged that they can be used not only to churn the cream and gather the butter, but also to wash, salt, and work the butter so that all these successive operations can be carried out without handling or exposure to flies and in an apparatus which permits of a controlled temperature.

In transferring the cream from the ripening-vat to the churn it is run through a tin strainer to remove any lumps of curd which might otherwise affect the appearance of the butter.

Butter color is usually also added to the cream before churning. Both annatto and synthetic colors are widely used. Different markets require different degrees of color. The commercial preparations used for coloring butter are employed in quantities varying from none in May and June (when the natural color of butter is highest) to about 2 ounces per 100 pounds of fat in winter when the butter would naturally have a much paler color than in early summer.

¹ Usually the ripening process is continued until 50 cc. of the cream neutralize about 35 cc. of tenth normal sodium hydroxide, using phenolphthalein as indicator. This is called 35 degrees of acidity. The acidity is also sometimes expressed as percentage of lactic acid, and is often measured by means of alkali tablets which contain a fixed amount of alkali along with enough phenolphthalein to serve as indicator.

Churning is usually continued until the fat has gathered into irregular, flaky, granular masses between the size of a grain of wheat and that of a kernel of corn. The buttermilk is then drawn off and the butter washed with pure water usually at a temperature about that at which the cream was churned or a little below. Warmer or colder water is sometimes used when it is desired to alter the texture of the butter.

Salting of butter has the object (1) of imparting the desired flavor, (2) of increasing the keeping quality, (3) of facilitating the removal of the buttermilk.

The amount of added salt desired in butter by different markets varies from 0 to 4 per cent, American markets tending as a rule to prefer a rather highly salted butter.

When the salting is done without removing the butter from the churn, the amount of salt added is calculated on the basis of the amount of fat known to have been contained in the cream.

The quality of the salt used is regarded as quite important. Good dairy salt should have a clean, white, silky appearance and should dissolve quickly. Woll¹ gives the following as the analysis of a sample of purest American dairy salt :

	PER CENT
Sodium chloride	99.18
Magnesium chloride	.05
Calcium sulphate	.54
Calcium chloride	.19
Insoluble matter	.03
Moisture	<u>.01</u>
	100.00

All of the salt contained in butter should dissolve in the water which the butter retains. Butter containing particles of undissolved salt is called "gritty." When the butter as packed contains undissolved granules of salt, these attract moisture and cause unevenness of appearance. This is one of the causes

¹ Bulletin 74, Wisconsin Agricultural Experiment Station.

of mottles in butter. In order to avoid mottling of butter from this or other causes, the buttermilk should be washed out as completely as possible and the salt carefully applied and well worked in. The washing out of the proteins in the buttermilk also results in a butter of better keeping qualities.

Working. The butter, having been washed and salted, is next worked to distribute the salt evenly, to bring the butter into compact form, and to press out any excess of water or diluted buttermilk. The amount of water left in the finished product is largely determined by the amount it is worked, since the more it is worked after it has become firm, the lower the percentage of moisture will be. For most markets the moisture must not exceed 16 per cent.

Packing. Extra quality butter is often put up in prints bearing the name of the farm or creamery where made. As the print butter must be firm in order to keep its shape well, it is apt to contain slightly less moisture than the butter put up in tubs.

Butter is said to keep best when packed in earthen jars, but as these are heavy and easily broken in transportation, they are usually replaced by wooden tubs made of ash or spruce, which must be well seasoned and free from odor. Before use the butter tubs are filled with saturated brine and allowed to stand and soak until the next day, then washed and scalded, thoroughly cooled, lined with paper which has been soaked in brine, and filled at once. This treatment should prevent molding of the butter in the tub, and it also swells the wood and so closes any small cracks which it may contain. Sometimes the tubs are paraffined inside or treated by soaking in brine to which has been added about three ounces of formalin to the gallon.

The butter is transferred from the churn or working table to the tub by wooden ladles which just before use are thoroughly scalded and then chilled in cold water. By means of the ladles, the butter should be smoothly and firmly packed into the tub

so as to leave no air spaces either in the butter or between the butter and the sides of the tub or at the top.

Stored butter should be kept at 50° F. or below in as dry a place as possible and separate from any other foods or anything from which it might absorb an odor.

The expense of making butter from the whole milk was investigated in Iowa and is reported to range in the different factories from one and one fifth to six cents, with an average of two and one fourth cents per pound of butter produced. The cost of ordinary creamery butter depends therefore much more largely upon the cost of milk or cream than upon the expense of manufacture.

Judging butter is very important in the industry because the price is so largely dependent upon the grade given the butter by the butter judge.

On a scale of 100 the weight given to the different factors of quality in America is usually as follows:

Flavor	45
Body	25
Color	15
Salt	10
Style	5

For discussion of judging, grading, and the market classification of butter, see McKay and Larsen, *Principles and Practice of Butter-making*, Chapter XX.

Composition of Butter

McKay and Larsen found the average composition of 221 samples of butter from 55 creameries in different parts of Iowa to be:

	PER CENT
Fat	84
Moisture	12.73
Curd	1.30
Salt and ash	1.97

The figures for *curd* include any milk sugar which may sometimes be present. Under present conditions of manufacture the curd is the least variable constituent. It is very generally kept below 2 per cent because if more than this is present the brine which exudes from the butter is apt to be noticeably milky, and such a butter would not be acceptable to the trade. In butter which is to be kept for some time special care is taken to keep down the protein as much as possible. Such butter will probably contain only 0.5 to 1 per cent of curd.

Preparations for increasing the amount of butter obtainable from a given amount of cream have been put on the market from time to time. Since in the ordinary manufacture very little fat is lost in the buttermilk, it is obvious that these butter increasers must act, if at all, not by a saving of fat, but by inducing the formation of a butter with a lower fat content. Usually the result is accomplished by the incorporation of an undue amount of curd and water by a sort of emulsification of buttermilk with the butter. Such a butter is of course fraudulent, and is also of very inferior keeping quality on account of its high protein content. Such frauds can be practiced only on a small scale, as a butter of this sort would be quickly detected and rejected by those engaged in the wholesale butter trade.

The *salt* in butter is both a flavoring and a preservative. A comparatively small variation in the salt content of butter is recognizable to the taste, and different consumers prefer very different amounts of salt. About 2 per cent of salt is demanded by most American markets. Some brands of butter are made extra salty with the idea that the consumer having acquired a taste for this will find ordinary butter "flat" and so will continue to demand the highly salted brand. On the other hand some consumers demand unsalted (so-called "sweet") butter, and this can usually be found in the market.

When unsalted butter is stored its flavor deteriorates and

becomes "cheesy," while salted butter deteriorates less rapidly and usually in a different manner.

Moisture is the most abundant and most variable constituent of butter aside from the fat. The amount ranges from 6 to 16 per cent, more than 16 per cent being forbidden both by legal and trade regulations in many states and in the large markets. Butter which exudes large drops of water is called "leaky" and is commonly supposed to contain excessive moisture, but this is not necessarily the case. Both the moisture content and the physical condition which make the butter "leaky" are largely influenced by the conditions which obtain during churning.

The United States Department of Agriculture, in 1902, made a systematic investigation of the moisture content of American butter as ordinarily manufactured. In 800 samples of butter from 400 creameries in 18 states the extremes were 7.20 and 17.62 per cent moisture; 85 per cent of the samples showed between 10 and 14 per cent, and the average of all was 11.78 per cent of moisture.

Composition of butter fat. Like all other natural fats butter fat consists of a mixture of glycerides of fatty acids. It is characterized, however, by containing more butyrin (yielding butyric acid) and less stearin (yielding stearic acid) than other food fats.

Browne made an extended study of the amounts of each fatty acid in a specimen of butter fat with the results shown in Table 48.

These figures represent the composition of a particular sample of fat and not necessarily the average. That individual samples vary considerably in composition is evident from the results of several independent investigations.

According to Browne, sickness, peculiarities of feed, and advancement in the period of lactation are the principal causes of irregularities in the composition of butter fat; certain feeds,

of which gluten meal is an example, tend to increase the proportion of olein in the butter, while beets and other roots have an opposite effect.

TABLE 48. FATTY ACID RADICLES IN BUTTER FAT (BROWNE)

FATTY ACID	CALCULATED AS ACID	CALCULATED AS GLYCERIDE
	<i>Per cent</i>	<i>Per cent</i>
Butyric	5.45	6.32
Caproic	2.09	2.32
Caprylic	0.49	0.53
Capric	0.32	0.34
Lauric	2.57	2.73
Myristic	9.89	10.44
Palmitic	38.61	40.51
Stearic	1.83	1.91
Oleic	32.50	33.95
Dioxy stearic	1.00	1.04
Total	94.75	100.00

The standard of the Association of Official Agricultural Chemists is as follows: "Butter is the clean, non-rancid product made by gathering in any manner the fat of fresh or ripened cream into a mass which also contains a small portion of the other milk constituents, with or without salt, and contains not less than 82.5 per cent of milk fat. By acts of Congress approved August 2, 1886, and May 9, 1902, butter may also contain added matter coloring."

Fuel value of butter. Atwater and Bryant estimated the average fat content of butter at 85 per cent, which according to modern factors of fuel value would yield about 3500 Calories per pound.

With increased knowledge and skill professional butter makers have tended to increase their "over-run" by leaving somewhat more water in the butter than formerly. If McKay

and Larsen's estimate of 84 per cent represents the present average fat content of butter, the average fuel value is about 3450 Calories per pound.

The above minimum standard of 82.5 per cent fat insures only a minimum of 3370 Calories per pound, but the average should of course exceed this minimum.

Process Butter

Butter of inferior flavor or which has become more or less rancid is often "renovated" or "processed." This usually consists in melting the butter, removing the froth or scum, and drawing off the curd and brine which settle out of the melted butter, blowing air through the melted fat to expel faulty odors, and re-churning the fat thus purified with fresh milk or cream.

In the butter markets, process butter is an established grade. In many states, however, restrictions are placed upon the sale of process butter, while good and bad grades of original butter are sold side by side without restriction.

A simple test much used to distinguish original butter from process butter or oleomargarine is to heat some of it in a tablespoon or small dish, with stirring, until it boils briskly, and stir two or three times thoroughly while boiling. Original butter boils without much noise but with an abundance of foam. Process butter and oleomargarine boil more noisily, sputtering like a mixture of water and fat in a frying pan, and give less foam than butter.

The definition and standard of the Association of Official Agricultural Chemists is as follows: "Renovated butter, process butter, is the product made by melting butter and re-working without the addition or use of chemicals or any substances except milk, cream, or salt, and contains not more than 16 per cent of water and at least 82.5 per cent of milk fat."

According to Wiley the quantity of renovated butter produced during the year ending June 30, 1905, was 66,290,421 pounds.

Oleomargarine (Margarine)

"Oleomargarine" in America, "margarine" in England, France, and Germany, is the term applied to butter substitutes made by churning fats other than butter fat with milk or cream to a butter-like emulsion.

The soft beef fat which was the original basis of these preparations is called "oleo oil" in America; Lewkowitsch states that in England it is called "oleomargarine."

Legislation in the United States has generally been such as to discourage the oleomargarine industry, and its volume for the census year 1909 is estimated at only about \$8,148,000, or about 2 per cent of the value of the butter industry.

According to Lewkowitsch Great Britain in 1906 imported butter to the value of £22,417,926 and "margarine" to the value of £2,223,645, *i.e.* the imported "margarine" equaled 10 per cent of the imported butter in value (doubtless more than 10 per cent in amount), and this exclusive of considerable quantities of edible fats which were worked up into butter substitutes in England. Lewkowitsch estimates the home production of margarine in the United Kingdom as over 100,000,000 pounds, or about as much as is imported.

Manufacture of oleomargarine. The commercial preparation of an artificial butter was first described in 1870 by Mège, a French chemist, who was led to study the subject through his desire to furnish to poor people and to sailors a cheaper and more stable article than ordinary butter. He sought to imitate the physiological process by which the body fat of a cow may become changed into milk fat and succeeded in obtaining a fat "which melted at almost the exact temperature of butter, possessed a sweet and agreeable taste, and which for most purposes could replace ordinary butter, not, of course, the finest kinds, but which was superior to it in possessing the advantageous peculiarity of keeping for a long time without becoming rancid."

The details of the process used by Mège, many of which are now known to be unnecessary, are given in his United States Patent, No. 146012, dated December 30, 1873, and in Bulletin 13, Bureau of Chemistry, United States Department of Agriculture, pages 10-12.

The chief fats used in the manufacture of oleomargarine are "oleo oil" prepared from beef fat and "neutral" lard. The preparation of "oleo oil" may be described first:

Oleo oil. The fat of freshly killed beeves, chiefly the fat of visceral cavity, known as "caul fat," is thoroughly washed, first in tepid and then in cold water, and then thoroughly chilled either by means of ice water or by hanging for some time in artificially cooled rooms. The hardened fat is then cut up and ground and the disintegrated mass transferred to a jacketed melting kettle.

Formerly this fat was rendered at 55° to 80° C. (130°-175° F.), the fluid fat thus obtained was allowed to cool slowly until a considerable proportion of the stearin and palmitin had crystallized out, the pasty mass then subjected to hydraulic pressure, and the fluid pressed out (about two thirds of the whole) was run into cold water and allowed to solidify into a granular mass, — the "oleo" or "oleo oil" of commerce.

According to Lewkowitsch the temperature of rendering is now much lower, not above 42° C. (107° F.), this temperature being maintained for a longer time by means of steam or hot water in the jacket of the kettle. At this temperature the tissue slowly sinks, and a part of the fat melts and separates at the top. Sprinkling salt on the mass assists in the settling of the tissue and the clearing of the surface fat. The latter is then run off and either allowed to cool to the proper point and pressed, or (for the better grades of oleomargarine) may be remelted and freed from the last portions of membrane and tissue by further standing and sprinkling with salt. Finally it is carefully cooled to the proper temperature for crystallizing out the

desired proportion of "stearin," and is sometimes held at this temperature for 3 to 5 days before going to the hydraulic presses.

Neutral lard. For the preparation of lard to be used in making butter substitutes the "leaf fat" of the hog is quickly removed, freed from flesh, chopped into small pieces, and then thoroughly washed with cold water. It is then rendered at a temperature of 40° to 50° C., yielding a practically neutral product known in the trade as Neutral Lard No. 1. When the leaf fat cannot be rendered at once, it is kept in refrigerating rooms until it can be worked up. This prolonged cooling process is considered by some an advantage, inasmuch as it is said to be more effective than simple washing in removing the "animal flavor."

The neutral lard or the oleo oil is, of course, brought to different degrees of hardness in different cases, a harder fat being prepared in case cottonseed oil or other oil is to be admixed.

The chief desiderata are that each fat (except the butter which is churned in later) shall be as free as possible from taste and odor, and that the final mixture of fats have practically the same melting point as butter fat for this climate; for a warm climate a little harder and for a cold climate a little softer.

Cottonseed oil especially prepared for use in butter substitutes is called "butter oil" and is considerably used, as is also ordinary cottonseed oil and cottonseed "stearin." In Europe sesame oil is used in the same way. Coconut fat and arachis (peanut) oil are also used in some cases.

Final mixing. The foreign fats having thus been obtained in proper condition and mixed in the desired proportions, the mixture is fed into a churn containing milk or an emulsified mixture of milk and butter (sometimes also cream). The amounts of milk, cream, and butter vary greatly according to the quality of product being made. In some countries the amount is restricted by law in order that the product may be easily

distinguishable from butter. In this country any proportions may be used, but the product must always be called oleomargarine, and whatever its quality is subject to the restrictions noted later. The foreign fats having been gradually churned into the milk (or milk and butter mixture) and the whole mass having been "pulverized" by means of rotating paddles into a granular emulsion which will not permit any subsequent crystallization of the beef fat, the product is cooled, washed, salted, and worked as in buttermaking.

Legal control. In the United States the oleomargarine industry has been regulated by the Federal Laws of August 2, 1886, and May 9, 1902. The latter law taxes uncolored oleomargarine 0.25 cent and colored oleomargarine 10 cents per pound. This prevents the use of artificial coloring matter in oleomargarine made and used in this country. For this reason preference is now given to fats having naturally a yellow color. Government officials have objected to the use of yellow fats in making oleomargarine, but have not been able to stop the practice. The oleomargarine now commonly sold is distinctly yellowish, though not nearly so yellow as is ordinary butter.

The United States law does not specify the fats to be used in making oleomargarine, but all mixtures of butter with other fats must be sold as oleomargarine and practically must be uncolored, since the tax of 10 cents a pound on colored oleomargarine is prohibitive. Factories must register with the Bureau of Internal Revenue and furnish the government with detailed reports of their operations. They are always open to Federal inspection.

In Great Britain since 1899 the maximum proportion of butter fat in oleomargarine is limited to 10 per cent. Since 1907 the water content is limited to 16 per cent and the factories are subject to inspection.

In France up to 1897 butter and oleomargarine could be mixed in any proportions provided the mixture was sold for

what it was. But by Law of April 16, 1897, the amount of butter which may be admixed with oleomargarine is limited to 10 per cent.

Germany and Austria forbid the direct mixing of butter and oleomargarine either during or after manufacture, and restrict the amount of milk which may be used in making the oleomargarine to 100 parts of milk or an equivalent amount of cream to each 100 parts of fat. In effect this limits the butter or milk-fat content of the finished product to about 3.5 per cent. These countries also require the use of 10 per cent of sesame oil in oleomargarine to permit its more ready detection.

In Denmark under the Law of Jan. 1, 1906, the proportion of butter in oleomargarine is limited to a maximum of 15 per cent, the color is restricted, and the product must contain 10 per cent of sesame oil.

In Belgium under Law of May 4, 1900, it is required that oleomargarine contain at least 5 parts of sesame oil per 100 parts of fatty matter and that it be further "earmarked" by the addition of 0.2 per cent of dry potato starch, which may readily be detected by the iodine reaction.

Vegetable Fats as Butter Substitutes

Edible fats of the consistency of butter are obtainable from a number of vegetable sources.

Any of the edible oils may be chilled and pressed at such a temperature as to leave a soft solid residue. This is a regular practice with cottonseed oil, the solid product being called "cottonseed stearin," although the proportion of stearic acid is not large.

Coconut and palm nut fat are of nearly the desired melting point in their natural state and so lend themselves readily to this purpose, but require careful refining to remove their characteristic tastes and odors. Different methods have been patented for the refining of these fats and no reliable information

is at hand as to which methods are most used, but the results are now sufficiently satisfactory so that large quantities of these fats are sold for food.

Lewkowitsch estimates the production of coconut and palm nut butters, in Europe in 1907 at 50,000 to 60,000 tons or 100,000,000 to 120,000,000 pounds.

At first the refined coconut oil was used as an adulterant of butter, and on account of containing a considerable proportion of lauric acid and appreciable amounts of fatty acids of still lower molecular weight it is more difficult to detect than oleomargarine; but methods for its detection were soon developed, and as the processes of refining were perfected and a more attractive product obtained it has come to have an independent market as an honest substitute for butter both as a culinary fat and (extensively) in the making of confectionary and fancy bakery products. The manufacturers as a rule attempt to keep their processes secret and often market their product under copyrighted names.

These products are not so largely used in this country as in Europe, largely no doubt because butter and lard are relatively cheaper here, and probably also in part because of the expense of importing from Europe, where the refining industry is principally developed.

Olive Oil

In comparison with other food fats, olive oil plays a relatively less prominent part in the United States than in many European countries. It has been estimated unofficially that about 350,000 gallons of olive oil are produced annually in California, and according to the United States Department of Agriculture the imports amounted in 1912 to 4,836,515 gallons. The total weight of olive oil consumed is therefore probably between 2 and 3 per cent of the weight of butter.

Olives for green pickles are gathered very soon after they reach

full size and before they have begun to color or soften, but for ripe pickles and for oil making olives are gathered when they contain the maximum amount of oil, which is soon after they are well colored and before they become black. If the olives are too green, the oil will be bitter; if too ripe, it will be rancid.

The flesh of ripe olives is about one half oil. When the skin is broken a considerable proportion of this oil exudes from the pulpy flesh, either spontaneously or under very slight pressure in the cold. This is called "virgin," "sublime," or "first-expressed" oil and the highest grades are obtained from selected, hand-picked olives.

In the manufacture of ordinary olive oil the olives are thoroughly crushed either by corrugated metal rolls or by heavy stones revolving in masonry trenches.

The crushed pulp is placed in fabric of woven esparto grass (in Europe) or coarse linen cloth (in California), and the fabric folded over it to make a cheese about three feet square and three inches thick. Ten or more of these cheeses are placed one above the other, with slats between them, and pressure is applied.

The oil obtained by pressure under these conditions is second in quality to the "virgin oil," and constitutes the bulk of the edible olive oil of commerce.

After obtaining as much oil as possible in this way, the cheeses are taken out, broken to pieces, mixed with hot water and pressed again, yielding a third-grade oil. Further yields of much inferior oil may be obtained by repeated pressing with hot water in very powerful presses or by extraction with solvents, but in California this is not usually done. The residual pulp is used for fattening swine.

In order to clarify the dark-colored oil obtained from the press, it is usually filtered first through cotton wool, then allowed to settle for 24 hours in funnel-shaped tanks from which the greater part of the sediment is drawn off, and finally run into settling tanks lined with tin or glass where the oil stands for 2 to

5 months, being repeatedly racked off (usually three times in all) until it is entirely clarified.

The flavor of olive oil, which chiefly determines its commercial value quite apart from any question of genuineness or purity, depends largely upon the variety of olive, its ripeness when picked, the manner of handling, the length of time it is stored before pressing, the temperature and pressure at which the oil is drawn, and other conditions of manufacture.

Chemically olive oil consists chiefly of olein, the glyceride of oleic acid.

According to the standards of the Association of Official Agricultural Chemists: "Olive oil is the oil obtained from the sound, mature fruit of the cultivated olive tree (*Olea europæa* L.) and subjected to the usual refining processes; is free from rancidity; has a refractive index (25° C.) not less than 1.4660 and not exceeding 1.4680; and an iodine number not less than 79 and not exceeding 90." "Virgin Olive Oil is olive oil obtained from the first pressing of carefully selected, hand-picked olives."

The purpose in setting limits to the index of refraction and "iodine number" in the standard for olive oil is to aid in distinguishing it from other edible oils of only slightly different physical and chemical properties.

Out of the first 25 prosecutions for adulteration or misbranding of olive oil under the Food and Drugs Act, 23 were because of the presence of cottonseed oil not properly declared, one was for short weight, and one was because the label bore a false statement that the oil had been inspected by a government chemist.

The courts have upheld the position of government that the term "salad oil" when used alone is understood to mean olive oil; but in one case in which a label bore the words salad oil in large letters and cottonseed oil in small letters the court decided against the government charge of misbranding.

In the administration of the Food and Drugs Act the following

notice has recently been issued: "Pending a final decision of this matter, no objection will be made to the use of the term Salad Oil on oils other than olive oil, when such oils are pure, harmless; and edible, providing the term Salad Oil be plainly qualified by the common name of the oil or oils actually used. These qualifying names should be stated on the label with a prominence equal to that of the term Salad Oil."

Other Edible Oils

Many fatty oils besides that of the olive are entirely suitable for use as human food.

The Association of Official Agricultural Chemists include among edible vegetable oils and fats of sufficient importance to warrant standardizing, the oils of *cottonseed*, *peanut*, *sesame seed*, *poppyseed*, *coconut*, *rape seed*, *sunflower*, and *maize*, as well as the solid fats *cocoa butter* and *cottonseed* "*stearin*."

Of these peanut oil bears the closest resemblance to olive oil in chemical and physical properties, and is used to a considerable extent as a substitute for olive oil in Europe, but not to such a large extent in this country because of the elaborate refining required to remove the characteristic flavor.

Cotton seed and sesame seed yield oils very similar to each other and not very different from olive oil in general nature but each possessed of characteristic color reactions by which it is readily identified. It is for the latter reason that sesame oil, which is abundant in Europe and is known to be a wholesome food, is required by the laws of some of the European countries to be added in the manufacture of oleomargarine as a means of making the latter easily distinguishable from butter.

Sesame oil is not produced in this country, and there is no inducement to import it in any quantity because cottonseed oil, having nearly the same properties and being equally adapted to the same uses, is produced here in such abundance as to supply the entire home market and leave a large surplus for export.

It is estimated that the average cotton crop of the United States yields about 12,000,000 bales of fiber and about 6,000,000 tons of seed and that about 4,000,000 tons of seed are crushed and pressed with the production of about 3,000,000 barrels of crude cottonseed oil annually (three fourths of the world's production). About half of this oil is refined and used as human food, but not all in this country, as a very large part of it is exported to Europe.

The modern process of refining cottonseed oil involves treatments (1) by sodium hydroxide, (2) with fuller's earth, and (3) by a secret method for removal of the "earthy flavor." The final product is nearly free from any characteristic flavor and is steadily growing in favor both as a substitute for olive oil and as a cooking fat. The highest quality refined cottonseed oil costs one third to one half as much as a medium-grade olive oil and has essentially the same food value since both are practically pure fats.

Lard and Lard Substitutes

Under the conditions ordinarily pertaining in the fattening and slaughter of swine, each hog yields about 30 pounds of lard. The refining of lard constitutes an important branch of the industry of slaughtering and meat packing, the exportation of lard for the year 1909 being reported at 528,722,000 pounds. How much lard is taken by the home market is not definitely known, since the statistics do not sufficiently separate lard from pork on the one hand and lard substitutes on the other.

Commercial lard is nearly pure fat, the total amount of other substances being usually less than one per cent.

Lard substitutes are usually mixtures of beef fat and cottonseed oil. The solid residual fat from which "oleo oil" has been pressed, and which is technically known as "oleostearin," is commonly used for this purpose.

Some of these "lard compounds" are widely advertised and

favorably known under trade names and sell for about the same price as lard.

Refined cottonseed oil is sometimes chilled and pressed at such a temperature that about one fifth of the whole is obtained as a solid which is called "cottonseed stearin," and may be used as a lard substitute either alone or in admixture with other fats. The other four fifths of the oil, being free from the more readily solidifiable glycerides, can be subjected to low temperature without yielding crystals or showing turbidity and is known commercially as "winter oil."

In recent years the transformation of liquid glycerides of unsaturated fatty acids into the corresponding saturated compounds which are solids, with resultant thickening or hardening of the fat containing such glycerides, has been developed on a commercial scale. Cottonseed oil is the material chiefly used in this country, and the "hydrogenation" is accomplished by heating with hydrogen in the presence of nickel as a catalytic agent, the process being carried to such a point as to yield a product of the appearance and consistency of lard.

It is said that experiments are now (1914) in progress to determine whether a small amount of nickel remaining in the final product is likely to have any physiological effects.

Place of Fats in the Diet

Fats have more than twice the energy value of either proteins or carbohydrates in nutrition, and it has repeatedly been seen in earlier chapters that the energy values of food materials which contain a mixture of nutrients are largely due to their fat content. The food fats which appear in commerce in an approximately pure state are closely similar to, if not identical with, those which have already entered into our consideration of the food values of meats, milk, grains, etc. Hence there is no occasion to question the general wholesomeness and food value of such staple food fats as butter, oleomargarine, lard, olive oil, cot-

tonseed oil, etc., and we need only consider whether these are of equal value with each other and whether their liberal use is likely to make the total fat content of the diet excessive or the diet one-sided in any way.

Comparative digestibility of fats. The fats ordinarily used as food by man do not differ greatly in the extent to which they are absorbed from the digestive tract under normal conditions. Such differences as have been found seem to be explained by the differing hardness or melting points of the fats. If the melting point of the fat lies much above the body temperature, the fat will not become sufficiently fluid in the intestine to be readily emulsified and digested. The following data determined by Munk and Arnschink are cited by Von Noorden in this connection:

NATURE OF FAT	MELTING POINT °C.	PER CENT LOST IN FECES
Stearin	60	86-91
Mixture of stearin and almond oil . .	55	10.6
Mutton fat	50-51	9.2
Mutton fat	49	7.4
Lard	43	2.6
Bacon fat	34	2.8
Goose fat	25	2.5
Olive oil	fluid	2.3

These results show good utilization and no significant differences in digestibility among fats melting at or below 43° C., while with melting points from 49° to 55° C. the losses were considerable, and with stearin melting at 60° C. much the greatest part failed of digestion. Notice, however, that the admixture of sufficient almond oil to lower the melting point a few degrees resulted in very greatly increased digestibility. Hence while stearin eaten alone is only slightly digested, yet fats

containing much stearin may be digested very well provided they also contain enough olein so that the melting point of the mixture as a whole is not much above body temperature. Since oleomargarine contains notably more stearin than butter it was at one time thought that it might show correspondingly larger losses in digestion; but repeated experiments have shown that oleomargarine (being made so as to have about the same hardness) shows practically the same small losses in digestion as does butter. Thus in experiments by Luhrig the coefficient of digestibility was 97.86 per cent for the butter and 97.55 per cent for the oleomargarine.

In experiments in which cooked oils and fats were fed to mice, Moore found for olive oil coefficients of digestibility of 96.70 to 98.71; for cottonseed oil, 94.43 to 97.95; for home-made lard, 96.45 to 97.17 per cent. In another series of experiments in which Moore fed uncooked oils to guinea pigs the results were lower and less regular but indicated that olive, peanut, corn, and cottonseed oils were all digested to practically the same degree.

As regards "digestibility" in the more popular sense of relating to the ease, comfort, and rapidity with which the digestive organs carry on their work, it may be said that the fats generally retard the secretion of the gastric juice and tend to make the food stay longer in the stomach. To the extent that the ease of digestion is inferred from the rapidity with which a meal passes from the stomach into the intestine the eating of fat appears to retard the process, and this is true to a greater extent the higher the melting point of the fat.

While the eating of much fat may thus prevent the digestion of food in the stomach from going forward as promptly and pleasantly as it otherwise might, it is unlikely that the fat will exert any direct effect tending toward discomfort except in the sense that if fat is overheated in cooking it may in part be decomposed with the production of irritating substances. It should also be remembered that if foods are cooked in or with fat in such

a way as to form a coating of fat over the other constituents of the food, the digestion of the proteins and carbohydrates may be retarded, since the materials which are coated with layers of fat will not be permeated readily by the saliva or the gastric juice. These latter possibilities of unfavorable action of fat are not properly chargeable to fat itself, but rather to the unintelligent way in which it is sometimes cooked.

Fats are less susceptible to objectionable decomposition by the bacteria of the digestive tract than are proteins and carbohydrates.

In metabolism fat can serve interchangeably with carbohydrate as fuel within very wide limits. The different food fats have nearly the same fuel value when in the same state of purity. Lard, olive oil, cottonseed oil, etc., are practically 100 per cent fat and have energy values of about 4000 Calories per pound, while butter as stated above contains a considerable percentage of water and salt, and shows usually 83 to 85 per cent of fat with about 3400 to 3500 Calories per pound. Recently it has been discovered that the energy value of its fat content does not express the entire food value or nutritive function of butter.

Osborne and Mendel, in the course of their extended feeding experiments with isolated food substances which have been referred to in earlier chapters, have found that diets otherwise sufficient fail to maintain growth and health unless they contain certain hitherto unrecognized substances, apparently of lipoid nature, which in practice are best supplied by the feeding of milk or butter. In general their results confirm and extend the observations published just previously by Stepp and by McCullom and Davis.

The work of Osborne and Mendel and of McCullom and Davis taken together indicate that the important substances in question are contained in butter, egg fat, and codliver oil, and are not contained in lard, almond oil, cottonseed oil, or olive oil.

These observations are very recent, and as yet we do not know

just how important these substances may prove to be and how much more than its energy value should be credited to butter in the evaluation of the various types of food.

Since the commercially isolated fats such as butter, lard, and the edible oils are practically devoid of protein and natural ash constituents, the question may properly be asked whether the free use of such fats may impoverish the diet either as regards protein or any specific chemical element to any significant extent.

It was shown above that the total butter consumption of the United States amounts to about three fourths to four fifths of an ounce per person per day. The amounts of all other commercial fats consumed are very much smaller, so that the total consumption of all commercial fats is probably only about equivalent to an average of one ounce of butter per capita per day. Inasmuch as this would furnish only 200 to 220 Calories per day, and as the butter has a food value not yet measured in quantitative terms in addition to its fuel value, it would seem that, even though butter is used more liberally here than in other countries, its use is not in the case of the average individual displacing other foods to an extent which need occasion anxiety at present. The corresponding question presents itself in more serious form in connection with the rapidly increasing use of refined sugar and will be considered in the discussion of the place of sugar in the diet (Chapter XI).

Fat, being a very compact form of fuel, properly finds its largest place in the diet in those cases in which the energy requirement is high, as in persons doing large amounts of muscular work or exposed to severe cold. In such cases there is largely increased need for fuel without any corresponding increase in the need for protein or for other specific nutrients. Here a large part or even all of the *extra* energy requirement may be met by feeding practically pure fats, and it has been found that the organism, whether at hard muscular work, or only moderate exercise, is able to digest quite large amounts of fat. It has been generally

believed that about 200 grams of fat per day is as much as can be digested and absorbed, though individual instances of good utilization of larger amounts might be cited.

Considerable variations in the amount of fat eaten do not necessarily have any marked influence upon the completeness with which it is digested and absorbed. Thus in a series of twelve digestion experiments conducted by Milner and published in the Report of the Storrs (Connecticut) Agricultural Experiment Station for 1905 (pages 131-138) in which the amounts of fat eaten per man per day ranged from 91 to 186 grams, the coefficients of digestion of the fat varied only from 95.5 to 97.9 per cent.

While it is true that the *average* consumption of fat is not excessive and that those who need an especially abundant fuel supply can use with advantage amounts of fat much greater than the average, it is probably also true that many persons of only average activity and energy requirement are using considerably more than the average amount of butter, which as already stated amounts to less than an ounce per person per day. A consumption of one pound of butter per person per week is more than twice the average amount, but instances of families in which butter is thus liberally used will doubtless be familiar to many of the readers of this book. In such instances, it will be well to consider whether some of the money spent for butter might not more wisely be expended for milk.

A pound of butter is equal in energy value to 5 quarts of milk, but in view of the proteins and ash constituents which the milk contains, it would probably be wise to consider that 3 quarts of milk fully equal 1 pound of butter as an asset in the dietary, except perhaps in those cases in which the energy problem distinctly predominates. To pay much if any more for a pound of butter than for 3 quarts of milk will usually mean either that an extravagant price is being paid for butter or that the milk used is below the quality which the consumer can afford and should demand.

If any considerable number of consumers should decide to buy less butter and more milk, the diminished demand for butter and increased demand for milk would result in bringing to market some of the milk now used for butter-making. This would not appreciably disturb agricultural conditions and would plainly tend toward a better conservation of resources for the community as a whole, because under present conditions the skimmed milk of the butter factories is not generally utilized to good advantage. Economically therefore the making of butter should, for the most part, be carried on in regions which are adapted to dairy farming, but too remote from cities and towns to send their milk to market, or in districts in which it is feasible to make good use of the skimmed milk.

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CHAPTER XI

SUGARS, SIRUPS, AND CONFECTIONERY

The Cane Sugar Industry

CANE sugar or sucrose, $C_{12}H_{22}O_{11}$, occurs widely distributed in the vegetable kingdom. It is found in the fruits and juices of many plants, usually mixed with more or less of the simpler sugars, glucose (dextrose) and fructose (levulose). The separation of the sucrose is commercially profitable only in the case of a plant whose juice is relatively rich in this sugar and contains but small proportions of other substances. Only two plants, the sugar cane and the sugar beet, play an important part in the world's supply of sugar. The manufacture of sugar from the juices of the maple tree and of the palm tree are relatively small industries whose products enter but little into the world's sugar trade. We shall therefore confine our study of the technology of the industry to the manufacture of sugar from the cane or the beet. The accounts which follow are very largely taken from lectures delivered at Columbia University during 1911 to 1914 by Dr. C. A. Browne and Dr. W. D. Horne.

Production of raw sugar from sugar cane.¹ The sugar cane, which is the oldest and best known sugar-producing plant, grows only in tropical and semitropical countries; it resembles in many ways the Indian corn, producing a jointed stalk varying from 6 to 12 feet or even more in length. The native home of the cane is India, and it is mentioned frequently in the old sacred books of the Hindoos and in ancient Chinese writings centuries before Christ. The Greek soldiers of Alexander the Great saw

¹ Browne, *School of Mines Quarterly*, April, 1911, and January, 1913.



FIG. 27. — Sugar cane ready for harvest (American Photo Co., Havana).

the sugar cane growing in India at the time of his conquest, and brought back stories of the wonderful reed which yielded a juice sweeter than honey. The Persians and Arabs carried the cultivation of the sugar cane westward, and we find that sugar was both grown and refined in the valleys of the Tigris and Euphrates in the tenth century A.D. The Crusaders found sugar cane and sugar factories in Syria and Palestine, and brought back samples of the product upon their return from the East. The Saracens introduced the cultivation of sugar cane into Sicily and the Moors into Spain; the Spaniards in their turn carried the sugar cane with them to the New World during their voyages of discovery and colonization; and so the sugar cane was carried from its original home in India throughout the entire tropical and semi-tropical world.

At present the countries which lead in the production of sugar from cane are British India, Cuba, Java, and the United States, including Porto Rico, Hawaii, and the Philippine Islands.

The cane is propagated by planting in plowed furrows the tops of the canes of the preceding crop. When the sprouts of young cane appear above ground, the fields are cultivated until the growth of the cane is well started or until the rainy season begins, and then left to grow for varying lengths of time depending upon the climatic conditions and custom of the locality. In Louisiana the whole period of growth is considerably less than a year; in Hawaii the cane is often allowed to grow for practically two years.

The sugar cane, when the crop is ready, is harvested by cutting off the stalk as close to the ground as possible, trimming off the green tops, and stripping off the leaves (Figs. 27 and 28). These and the other agricultural operations of planting, fertilizing, and cultivating require a large amount of labor, the expense for which makes up about three fourths of the cost of the raw sugar, the remaining one fourth being due to the expense of manufacture.

The composition of the stalks and the expressed juice of the



FIG. 28. — Harvesting sugar cane (American Photo Co., Havana).

sugar cane vary considerably. The general range of the different constituents as compiled from analyses made in different countries is given in the following table (Table 49) :

TABLE 49. COMPOSITION OF SUGAR CANE AND ITS JUICE (BROWNE)

	WHOLE CANE	CANE JUICE
	<i>Per cent</i>	<i>Per cent</i>
Water	67-75	80-86
Dry substance	33-25	20-14
Fiber (cellulose, etc.)	10-15	
Sucrose	11-16	12-18
Invert sugar	0.5-1.5	0.5-2.0
Ash	0.5-1.0	0.4-0.8
Nitrogenous substances	0.4-0.6	0.1-0.4
Gums, acids, etc.	0.2-0.5	0.3-0.6
Wax and fat	0.4	0.2

Individual cases may show variations above or below these figures.

The sugar cane after it is hauled to the factory is first **passed through mills** to remove the juice (Fig. 29). The cane mills are of all kinds and types, and range from the crude ox-driven mills employed in the Philippines and other primitive countries, to the high-power, steam-driven hydraulic nine- and twelve-roller mills employed in Cuba, Java, Hawaii, Porto Rico, Louisiana, and other countries where the most modern machinery is used. In the best-equipped factories the cane is delivered by an endless carrier to huge corrugated crushers, which reduce the stalks to a thick blanket of pulpy fiber, removing at the same time some 50 per cent to 60 per cent of the juice. The crushed stalks pass next through a mill of 3 rollers, where still more of the juice is removed; and then through a second, third, and sometimes a fourth set of such rollers, the hydraulic pressure upon the rollers being increased at each mill in order to remove more and more of



FIG. 29. — Cane mill with corrugated crusher and three sets of rolls (American Photo Co., Havana).

the juice. It is also customary to wet the pulp with a thin spray of water between the sets of rollers, the water thus soaked up facilitating the removal of the residual sugar by the succeeding roller. This process of wetting, or maceration, as it is called, is highly important, but requires to be carefully controlled; the water added must of course be afterwards evaporated, and the question which the chemist must decide is when the cost of evaporation begins to exceed the value of the extra sugar recovered. The quantity of water used for wetting the fiber is usually about 15 per cent, *i.e.* 15 parts of water per 100 parts of normal undiluted juice, although 25 per cent and more is sometimes used. With 15 per cent maceration about 90 per cent of the sugar in the cane is extracted in the juice; with 25 per cent maceration over 95 per cent of the sugar may be extracted. The residue of cane fiber as it leaves the last mill contains about 45 to 50 per cent moisture and from 3 to 5 per cent sugar, *i.e.* from 5 to 10 per cent of the original sugar in the cane. This residue of fiber is called "bagasse" and is burned under the boilers; it constitutes the chief, and in some countries the only, supply of fuel for operating the sugar factory.

The *polarization*¹ and "purity" of the raw juice are the first important factors to be determined in the chemical control of a cane sugar factory. The "polarization" of the juice will give the approximate sugar content; the dissolved solids in the juice are estimated by means of a floating hydrometer called a Brix spindle. The polarization of the juice multiplied by 100 and divided by the reading of the Brix spindle gives the "purity" of the juice. Good cane juices run over 90 per cent purity, juices running from 85 to 90 per cent purity are fair, and from 80 to 85 per cent medium. Juices with a purity below 80 per cent are poor and very unsatisfactory to work.

¹ The term "polarization" implies the estimation of sugar by means of the polariscope; see, for example, *Methods of Organic Analysis*, Revised Edition, pages 79-100.

The second step in the manufacture of cane sugar is the **clarification** or purification of the raw juice. The best clarifying agent and the one that has been used from time immemorial is lime.

Many methods of using lime are practiced, only one of which need be described here. Cane juice as it comes from the mill



FIG. 30. — Clarifying cane juice (American Photo Co., Havana).

is slightly acid. One method of clarification is to neutralize this free acid of the juice by adding lime to slight alkalinity, and then to heat to boiling (Fig. 30). The lime combines with the organic acids and phosphoric acid of the juice, and the heat coagulates the proteins present; a thick scum of impurities rises to the surface, which is skimmed off and the hot juice is run into settling tanks, when the suspended impurities settle out, or, more

often the juice is passed through filter presses (Fig. 31), and the impurities removed in this way. The residue of impurities, called "filter press cake," contains the phosphates and nitrogenous matters of the juice and is returned to the canefields as a fertilizer.

In many factories the cane juice is sulphured before liming; sulphur dioxide, produced by burning sulphur, is led into the



FIG. 31. — Filter presses in sugar factory (American Photo Co., Havana).

juice to a certain point of acidity; the free acid is then neutralized with lime and the juice heated as first described. The sulphurous acid has a favorable bleaching effect upon the juice and the mechanical separation of the impurities is greatly facilitated by its action. Objections against its employment are the increase in scale (mostly calcium sulphate) which forms upon the

tubes of the evaporators and the contamination of the molasses with sulphites. In some factories phosphoric acid is used with the lime.

In some countries, notably in Java, lime is added to the juice to strong alkalinity and the excess of lime then removed by means of carbon dioxide. This process of clarification, called carbonatation, is the only one used in beet sugar manufacture. It works well with cane juices when but little invert sugar is present. If the latter occurs in large amounts, the lime forms dark-colored soluble compounds which not only give a dark colored sugar but interfere seriously with the work of evaporation and crystallization. Such juices are said to be lime-burnt. The tendency at present in cane sugar manufacture is against carbonatation and all other methods of strongly alkaline clarification.

The third process in the manufacture of cane sugar is that of **evaporation**. In primitive countries and out-of-the-way plantations evaporation is carried out over the direct fire in open pans or kettles. The juice is either boiled down in one single kettle or passed through a train of pans; when crystallization of the sugar has begun, great care must be exercised that the mass be kept in constant motion; otherwise there will be burning and caramelization next to the surface of the evaporator. Such caramelization is in fact unavoidable, and all open kettle sugars are characterized by a dark color and by an agreeable aromatic taste which is preferred by many to that of the pure refined sugars. In some countries the cane juice after evaporating to a thick, pasty mass is allowed to cool and solidify, just as molasses candy hardens after cooling. This solidified mass is called *concrete sugar* and is ground up in mills and marketed as a coarse lumpy sugar of very uneven composition. This concrete sugar contains of course all the molasses with the soluble impurities of the juice. Such sugar constitutes at present almost the sole output of the Philippine Islands. It is shipped to this country

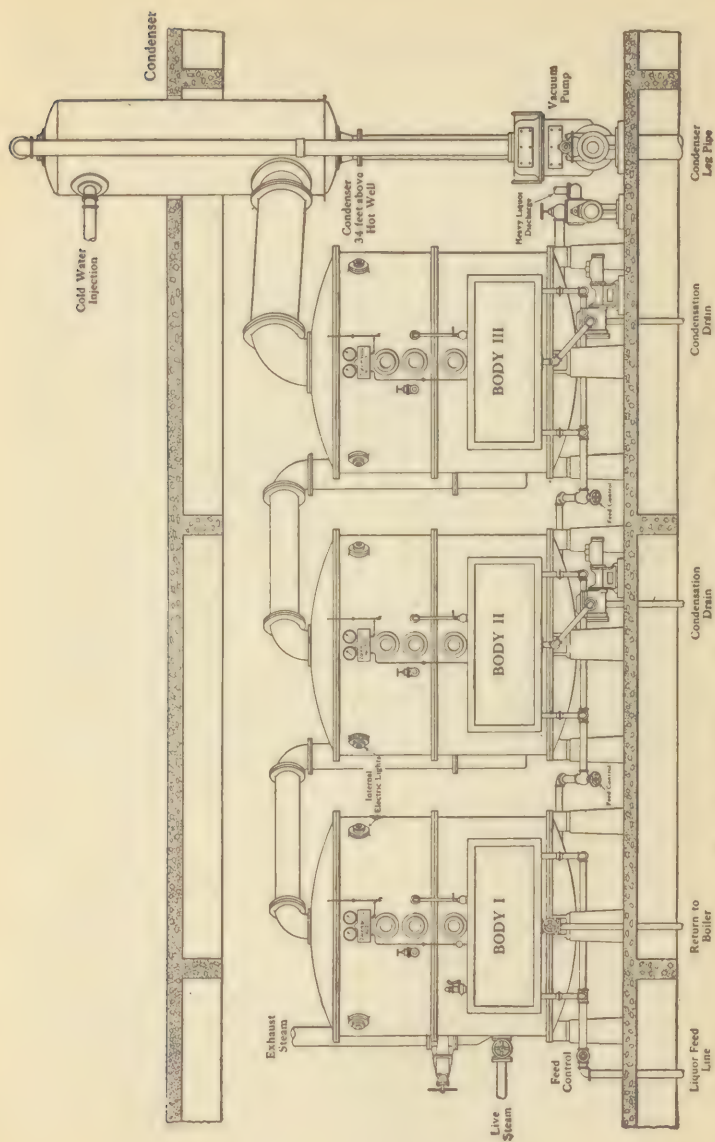


FIG. 32. — Arrangement of triple effect. Zaremba evaporators.

in mats weighing about 50 pounds and comes in 3 grades which contain all the way from 80 per cent to about 90 per cent pure sucrose.

In other primitive countries, especially in parts of South America, the juice is not evaporated to concrete, but only to the consistency of a thick mush; this mush is run into hogsheads having a fine perforated bottom through which the molasses, or mother liquor surrounding the crystals of sugar, percolates. When as much as possible of the molasses has drained away, the residue of sugar is removed and sold as *muscovado* sugar. This is purer than concrete sugar and polarizes sometimes as high as 92 per cent. It is usually quite moist and for this reason very liable to deteriorate.

In the open kettle process of evaporation there is always considerable loss of sugar due to caramelization and inversion caused by the high temperature of heating, which may be from 20 to 30° F. above the boiling point of water. To avoid these losses all modern sugar factories employ **vacuum evaporators** which allow evaporation to proceed at a temperature much below the boiling point of water and at the same time permit the utilization of waste steam from the exhaust of the engines and other points about the factory. Vacuum evaporators are manufactured in many different forms, and are arranged usually in a series of 2, 3, or 4, sometimes even as high as 5 or 6, the combination being called double, triple, quadruple, quintuple, or sextuple effects. In the first vessel of an effect, a lower vacuum is maintained than in the second, a lower in the second than in the third, and so on, the temperature of boiling for each succeeding vessel is thus progressively reduced. Figure 32 shows the general arrangement of a triple effect. The steam which is evaporated from the juice in the first vessel (or "body") goes to heat the coils of the second, the steam from the second vessel goes to heat the coils of the third, the reduction in temperature of the steam for each vessel being of course counterbalanced by the

greater vacuum and lower temperatures necessary for boiling. With a long series of vessels, as in a quadruple, quintuple, or sextuple effect, the thin juice in the first body may be boiled under atmospheric pressure or even at a few pounds above this; this is necessary in order to get a high enough temperature to carry sufficient heat through to the last evaporator. The sub-

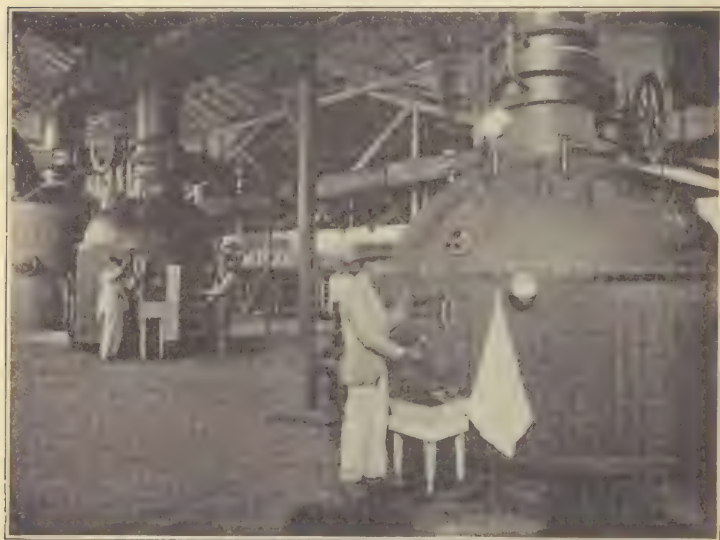


FIG. 33. — Vacuum pans in sugar factory. Operator in foreground using "proof stick" to withdraw test portion of contents (American Photo Co., Havana).

ject of multiple evaporation is a science in itself, and exhaustive treatises have been written upon this one single phase of sugar manufacture.

After the clarified juice has been evaporated to a sirup we come to the fourth stage of the process of modern sugar making, the **graining** or **crystallizing** of the sugar. This is accomplished in a vacuum pan (Fig. 33) which is operated in much the same way as one of the vessels of an effect; in the case of the vacuum

pan, and the same is true with many other effects, the process is assisted by connecting the outlet with a vertical condensing column 34 feet or more high (often extending above the roof, as may be seen in Figs. 35 and 36 beyond). A stream of cold water flows through the column, and this serves both by rapid condensation of the steam and by the barometric pull of its column of liquid to maintain a high degree of vacuum.

A charge of sirup is first drawn into the vacuum pan; this sirup as it leaves the evaporators has a specific gravity of about 1.25 (or about 50 per cent solids) and is boiled down in the vacuum pan to a specific gravity of 1.50 or about 90 per cent solids. The ebullition in the vacuum pan is violent and unless the sugar boiler is careful some of the sirup may be carried over with the vapor into the condenser; this is called *entrainment* and is a source of frequent losses in sugar manufacture. In all modern sugar factories the chemist makes constant examination of the condensation water, so that any loss due to this cause may be promptly detected and stopped.

The handling of the vacuum pan requires more skill than any other operation of the sugar house; care must be taken to avoid entrainment and care must be taken to build up crystals of uniform grain or size. The usual practice is to boil down the first charge of sirup to what is called "string proof," *i.e.* to the point when a few drops of sirup withdrawn from the pan will draw out between the fingers in fine strings or threads. When this point is reached, a large charge of fresh cold sirup is drawn into the pan, the sudden cooling of the supersaturated contents starting the formation of innumerable fine crystals. These first crystals constitute the foundation so to speak of all the sugars obtained in a given boiling or strike of the pan. The boiler aims to build up these crystals without forming new ones; he aims from now on to avoid supersaturation and to avoid sudden chilling through drawing in too much sirup at one time. He controls his process by drawing out samples every few minutes

and examining these upon glass against a light ; if he sees fine new crystals appearing among the old ones, he reduces the vacuum a little, thus raising the temperature and dissolving this false grain as the fine crystals are called. By skillful manipulation, which only comes with long practice and experience, the sugar boiler is able to build up his crystals to any desired size. The



FIG. 34. — Horizontal cylindrical crystallizers with mixing tank and centrifugals beneath (American Photo Co., Havana).

usual practice is a crystal about the size of ordinary granulated sugar ; in certain localities, however, a large crystal is favored, as, for example, in Peru, where the sugar is boiled slowly and for a long time, thus building up a very large grain. The attachment for withdrawing samples of sirup from the vacuum pan is called the "proof stick."

When the vacuum pan is filled with a thick magma of sugar

crystals, of about the consistency of mortar, the steam is shut off, air is admitted, the bottom of the pan opened, and the entire contents dumped into a mixer, which keeps the mass in slow movement by means of revolving arms. This mixer is situated over a row of centrifugal machines; the mass of crystals (sometimes called *masse cuite* from the French, or *Füllmass* from the German) is drawn off gradually in successive charges into the centrifugals. The inner walls of the latter are lined with fine brass meshing and as the drums are rotated the *masse cuite* is whirled against the meshing, which retains the sugar but allows the molasses to pass through. After spinning for a few minutes until as much of the molasses is removed as possible, the revolving mass of sugar may be sprayed with a fine spray of water or a jet of steam in order to remove more of the film of molasses which remains adhering to the crystals; the amount of spraying depends upon the whiteness of sugar desired. In Louisiana a very pure, white sugar is made by spraying with several sprinklings of water; such sugar is over 99 per cent pure sucrose, the remainder being mostly moisture. In Cuba and Porto Rico they aim to make a 96 per cent sugar. In Hawaii and Java a sugar testing about 97 per cent is desired. Spraying will, of course, dissolve some of the sugar, so that the process is one which must be carefully controlled.

When the molasses has been removed as completely as possible, the centrifugals are stopped and the sugar emptied through the bottom of the drum into a conveyor, by which it is carried to the bagging department, where it is prepared for shipment. The raw sugar from the centrifugal contains considerable moisture, and in some countries the sugar is dried in revolving drums before being bagged. This drying is advantageous for two reasons: first, the excess moisture is removed, thus saving the cost of transporting water; and, second, the sugar is sterilized and protected against the attacks of ferments and bacteria. The drying of raw sugar is not practiced in Cuba, Porto Rico,

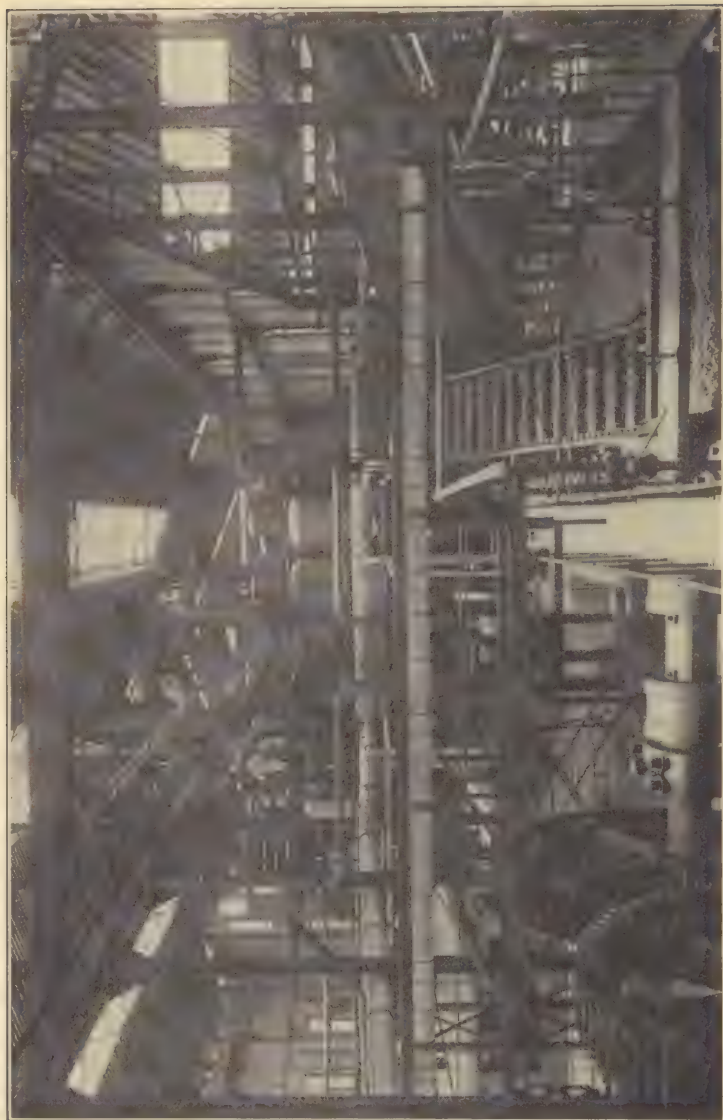


FIG. 35. — View in a sugar factory showing multiple effect evaporators in the background (American Photo Co., Havana).

or Louisiana, but is carried out in Java and the Hawaiian Islands, where the sugar has to be shipped long distances for refining. The storage of undried raw sugar for long periods of time is a risky operation, as many speculators in sugar have found to their cost.

The sugar which is made from the pure juice of the cane is called "first sugar" and the molasses drained from this sugar is called "first molasses." The latter still contains a large amount of sucrose, and various processes are used to recover as much of this as will crystallize. The first molasses is sometimes boiled down again in the vacuum pan and a second crop of sugar crystals obtained; this is the second sugar and the molasses obtained from this the second molasses. The second molasses may be boiled over again and a third sugar obtained, the molasses from which is the third or final molasses. Of course, as the sugar is removed the impurities become more and more concentrated in the molasses, until finally a thick stringy mass is obtained which will no longer crystallize. Such a molasses may still contain, however, 30 per cent sucrose; there is also present about 30 per cent invert sugar, 8 to 10 per cent of ash, and 8 to 10 per cent of gums, organic acids, amino compounds, etc.

The tendency of modern methods in cane sugar manufacture is against the repeated boiling of molasses, and the aim is to get as much sugar as possible in one operation. Many processes have been devised to attain this end. One method is to take the molasses from the first strike of sugar, draw this into the vacuum pan with the sirup for the succeeding strike, and boil the two down together. The *masse cuite* from this mixture is then run while still hot into large tanks, called *crystallizers* (Fig. 34), where it is kept in slow motion by means of revolving arms; as the mass cools and thickens more molasses is drawn to keep the proper degree of fluidity. When no more sugar will crystallize, as determined by analysis of samples, the contents



FIG. 36. — Sugar factory showing tops of condensing columns (American Photo Co., Havana).

of the crystallizer are spun out in centrifugals and the molasses withdrawn from the factory.

Several of the features above described are shown in Fig. 35. In the foreground at the left are the large wheels of the cane mill; at the right is the conveyor which carries away the bagasse. In the background a multiple effect evaporator may be seen at the center, while slightly to the left is the condensing column, which extends through the roof. At the top of each of the condensing columns of the factory in which these photographs were taken is a small covered platform easily seen above the roofs in Fig. 36.

Sugar Refining¹

The process of manufacture described above yields "raw sugar," which is usually from 95 to 98 per cent pure. The removal of the remaining impurities constitutes the "refining" of the sugar and is usually carried on in places where fuel is more abundant than in the tropical countries where the sugar cane is chiefly cultivated, since about 25 pounds of coal are consumed in refining 100 pounds of sugar. The difference in price between raw and refined sugar is usually 0.7 to 0.9 cent per pound and the cost of refining is estimated at 0.6 to 0.65 cent per pound, leaving a margin of profit so small that it is necessary for the operation to be conducted on a large scale in order to make it remunerative. In the United States the industry is carried on in a relatively small number of large establishments in or near the principal ports on the Atlantic and Pacific coasts.

Nearly all of the three million tons of sugar brought into the United States² annually is refined in about 20 establishments. Thus the average output of the refineries now in operation is

¹ Horne, *School of Mines Quarterly*, April, 1911.

² At present (1913-1914) about three fourths of the sugar used in the United States is imported; that produced in the country (about one fourth) is for the most part refined at the point of production.

about 1,000,000 pounds of sugar per day each, some establishments having a much larger output than this.

In principle the refining process consists in washing off as much as is practicable of the molasses which adheres to the crystals of raw sugar, then dissolving the crystals, purifying and decolorizing the solution as thoroughly as possible, and recovering the sugar in a purified state by recrystallization. While the process is simple in principle, the large scale upon which it must be carried out and the extreme precautions necessary to guard against apparently small losses if the industry is to be economically successful require elaborate equipment and constant chemical control.

As the sugar, either in granular form or in solution, is passed through a number of operations in a continuous stream, it is found advantageous to build the refineries several stories high so that after the first lifting of the material its transportation from place to place for the successive steps of the processes may be effected chiefly by gravity.

The raw sugar is usually carried to the top of the building by means of a bucket elevator and **washed** by mixing with a small amount of sugar sirup and then separating in centrifugals, the sugar in the centrifugal being sometimes sprinkled with a little water for further purification.

After this washing the sugar usually has a purity of about 99, *i.e.* of the total solids in the moist sugar about 99 per cent is sucrose.

The sugar is then dissolved in hot water, this step being technically known as **melting** the sugar. The "melting" process is accomplished by running the sugar into water contained in steam-heated pans, the proportions and the heating being so regulated as to obtain a solution of 28 to 30° Baumé and a temperature of 150° to 170° F. A higher temperature might result in darkening the solution by slight decomposition of some of its constituents.

The hot solution then goes to the *blowups* for **clarification**, which is accomplished by adding a very small amount of acid calcium phosphate and then enough milk of lime to make the mixture neutral or very faintly alkaline. The precipitate thus formed carries down such impurities as gums and proteins, as well as suspended particles, and also removes a part of the coloring matter. The precipitate is removed by running the liquid through **Taylor filters**, which consist of twilled cotton bags about six feet long encased in strong, coarse-meshed hempen sheaths. A single filter box may contain 400 or more of these bags, each attached to the filter head by means of a metal bell and socket. The bags soon become clogged and so require frequent changing and washing; the wash water must be utilized in such ways as to avoid either a loss of sugar or a waste of fuel in evaporating more water than is necessary.

The filtrate from the bags is clear but not colorless. Most of the color is removed from this filtrate by passing it through **boneblack filters**. These are large, strong iron cylinders, often 10 feet in diameter and 20 to 30 feet high, filled with boneblack through which the sugar solution flows very slowly, usually at about the rate of one foot per hour. On account of the immense amounts of boneblack required in a modern refinery, this part of the process requires very careful control in order to use the boneblack or "char" as economically as possible. Freshly charred boneblack removes the color from the sugar solution almost completely, but with accumulation of impurities in the pores of the char it naturally becomes less effective until finally the filtrate shows so much color that it must be re-treated and the boneblack must be washed and sent to the "char house" for reburning. Every reburning or "revivifying" leaves the pores of the boneblack somewhat clogged by the added carbon from the absorbed impurities, so that after 10 or 12 reburnings it is no longer economical to use. In the Weinrich oxidizing revivifier the reburning is carried out with a limited supply

of air designed to burn out the carbon of the impurities but not that of the original char, and thus to prolong the usefulness of the boneblack.

The sugar solution which has passed the boneblack filter, and is both clear and practically colorless, is **evaporated** in vacuum pans of 1000 to 2000 cubic feet capacity, wherein the sugar solution is "boiled to grain" and concentrated to a low water content. In order to accomplish this satisfactorily a vacuum is first created in the pan, some sugar solution admitted, and steam then passed through the heating coils and the solution concentrated until supersaturated. The exact point to which the concentration should be carried is determined by an experienced workman, who withdraws samples from the pan by means of a "proof stick," which is a long brass rod sliding through an air-tight fitting in the side of the pan and carrying a cup-like depression by means of which a small sample of the liquid in the pan can be removed without disturbing the vacuum. The test portion thus withdrawn from the pan is examined by drawing between the thumb and finger, and, when the exact degree of viscosity necessary to insure the immediate production of "grain" is found, more of the sugar solution is admitted to the pan, thus chilling its contents and starting the crystallization, which is then continued as in the corresponding operation of raw sugar production described above, until the pan is charged with a magma of crystals and mother liquor, which is then dropped into the *mixer* on the floor below.

In the **mixer** or **crystallizer** the mass is thoroughly stirred while cooling and is then allowed to fall into the centrifugals, where the mother liquor, usually known as *refinery sirup* rather than molasses, is thrown out through the perforated walls of the rotating drum, leaving the mass of crystals, which is sprayed lightly with water for the further removal of the sirup, and usually with a solution of ultramarine or "permitted" blue dyestuff in order to offset the tendency toward a slightly yel-

lowish color due to the very minute trace of mother liquor which still adheres to the crystals.

The washed sugar from the centrifugals is either barreled directly as "confectioner's sugar," pressed into cubical or domino form, or sent to the **granulator** to be made into the ordinary granulated sugar of commerce.

The granulator is a long inclined revolving cylinder heated by a current of hot air and provided with paddles to keep the sugar stirred and screens to separate the crystals into standard sizes. After granulation and sifting the sugar is barreled and sent into commerce.

The Beet Sugar Industry

About the middle of the eighteenth century Margraf succeeded in separating about 6 per cent of sugar from beets, and later (1769) Archard in Austria established the first beet sugar factory; but the beet sugar industry first became of commercial importance when the European supply of imported sugar was shut off by the blockade established during the Napoleonic war. The industry is commonly considered as dating from about 1810.

At about this same time the polariscope was developed into a practicable apparatus for determining sugar, and it became possible to test individual sugar beets, and plant for seed the ones of highest sugar content. By breeding systematically with constant chemical control, the average sugar content of the beet has been more than doubled, beets showing 16 to 18 per cent of sugar being now not uncommon, while in some cases from 20 to 24 per cent of sugar has been found. The sugar beet thrives in temperate climates. For the year 1912-1913 the countries showing largest production of sugar from beets were (in order): (1) Germany, (2) Austria, (3) Russia, (4) France, (5) the United States.

Beets of medium size are usually of better quality than large

ones. The average composition of the sugar beet and its juice is given by Browne as follows (Table 50):

TABLE 50. COMPOSITION OF SUGAR BEET AND ITS JUICE (BROWNE)

	SUGAR BEET	SUGAR BEET JUICE
	<i>Per cent</i>	<i>Per cent</i>
Water	75-85	78-84
Dry substance	15-25	16-22
Fiber (cellulose, etc.)	4-6	
Sucrose	12-16	13-17
Invert sugar	0.0-0.3	0.0-0.3
Ash (salts)	0.8-1.5	0.6-1.0
Nitrogenous substances	1.5-2.5	0.8-1.5
Gums, acids, etc.	0.4-0.8	0.3-0.6
Wax, fat, etc.	0.2	

It will be noted, that there is more water and less fiber in the sugar beet than in the sugar cane; there is also more ash (or salts) and more nitrogenous matter, but much less invert sugar, in the beet than in the cane. These differences in composition have an important bearing upon the differences in process of manufacture.

The beets, after they are dug and have had their green tops removed, are hauled to the factory; they are first washed to remove adhering dirt and then passed over knives which reduce them to fine slicings or chips.

The fine slicings are next carried by a conveyor to the diffusion battery, which consists of a series of tall boiler-shaped cylinders called cells. These cells are connected by pipes, the outlet from the top of one cell passing downward into the bottom of the next and so on around. Each cell is filled with beet slicings through a manhole at the top and when full is tightly closed with a cover which is clamped into place. Twelve cells connected in series usually constitute a battery, and when all are filled,

warm water of about 80° C. is passed through the system. The water circulating upwards through each cell removes the sugar from the beet slicings and becomes richer and richer in sugar with each succeeding cell. Heaters are placed between the cells so that the circulating water is kept always at the right temperature. When the water has made a complete circuit through the 12 cells of the battery, the slicings in the first cell are practically exhausted; this cell is then thrown out of circulation, emptied of exhausted chips, refilled with fresh slicings, and reconnected with the system, while the second cell undergoes replenishing. The process is thus a continuous one; 10 cells are always in circulation, while one is always being emptied and one always being refilled.

The exhausted slicings from the diffusion cells are dried by the heat of the flue gases from the boilers and are then sold as a cattle food.

The diffusion juice as it leaves the last cell of the battery contains from 12 to 15 per cent sugar and is ready for clarification. The juice is first treated with a considerable excess of lime, and the dissolved lime precipitated by leading in a stream of carbon dioxide. This process is called "carbonation."

After the first treatment with lime and carbon dioxide the precipitated calcium carbonate and other impurities are filtered off in filter presses and the juice subjected to a second carbonation.

The juice from the second carbonation is again filtered, when it is evaporated, grained, and centrifuged, these processes being carried out essentially as described for cane juice.

There is a great difference in the physical properties of raw cane sugar and raw beet sugar. Raw cane sugar has usually a fragrant odor and a pleasant taste which many prefer to the refined product, while raw beet sugar has a bitter and nauseating taste and an odor suggestive of glue.

In this country beet sugar is usually refined in the same factories in which it is extracted from the beets.

Development and Extent of the Sugar Industry as a Whole

In the above outlines of the production of sugar from cane and from beets the development of these industries has been briefly mentioned. Speaking generally, the beet sugar industry has been developed more quickly and more scientifically. Until 1810 there was no beet sugar industry, and in 1852, of the world's supply, the cane furnished six times as much sugar as the beet; but under the application of strict scientific control the beet sugar industry developed until, in 1884, the production of sugar from the two sources was about equal. By 1899 almost twice as much sugar was made from beets as from cane, largely, however, because the sugar industry in Cuba had been almost extinguished by war. Since the restoration of peace in Cuba, modern methods have been introduced into the cane sugar industry there, as was already being done in Hawaii, Java, and other cane-growing countries. In 1907 the production of sugar from beets and from cane was again about equal and has remained approximately so. The world's production for the year 1912-1913 is estimated at 18,144,638 tons, of which 9,178,574 tons were attributed to the cane and 8,968,064 tons to the beet. The production of each of the ten leading countries for the same year is given by Browne as follows:

(1) Germany	2,700,913 tons	(beet)
(2) British India . . .	2,583,600 tons	(cane)
(3) Cuba	2,428,537 tons	(cane)
(4) Austria	1,901,615 tons	(beet)
(5) United States and its Colonies	1,770,837 tons	{ 1,146,773 (cane) 624,064 (beet)
(6) Russia	1,374,500 tons	(beet)
(7) Java	1,331,180 tons	(cane)
(8) France	960,900 tons	(beet)
(9) Holland	316,177 tons	(beet)
(10) Belgium	298,584 tons	(beet)

Of the sugar attributed to the "United States and its Colonies" somewhat more than half was produced in Hawaii, Porto Rico,

and the Philippines, and somewhat less than half (about 800,000 tons) in the continental United States.

The total amount of sugar used in the continental United States is nearly 4,000,000 tons or 8,000,000,000 pounds, or about 85 pounds per capita, annually.

Only England and Denmark show an apparently larger per capita consumption of sugar than the United States. Since England exports considerable quantities of jams and marmalade, and Denmark of sweetened condensed milk, and the sugar entering into these products is not deducted in estimating the apparent per capita consumption, there is some doubt whether the actual per capita consumption is larger in any other civilized country than in the United States.

The money value of the sugar consumed in the United States is usually about \$400,000,000 per year.

By-products of Sugar Manufacture

The use of molasses and refinery sirup as human food will be considered later. The following account of the agricultural and industrial utilization of other by-products is condensed from a paper by Browne in the *School of Mines Quarterly* for July, 1913.

It may be stated as a general rule of all manufacturing that the number of by-products and the means for their utilization increase with the improvements in technical processes. This is particularly the case with the sugar industry.

The by-products of sugar manufacture in the more progressive countries are so numerous that it is possible to cover the field of their utilization only in the most superficial manner. In treating our subject we shall find it in many ways more convenient to subdivide it according to the character of by-product, as follows:

1. The utilization of the cellular refuse of beet and cane.
2. The utilization of the impurities removed in clarification.
3. The utilization of the waste molasses.

Utilization of the Cellular Refuse of Beet and Cane

In discussing this topic, we must bear in mind the differences between the physiological structure of these two plants, and also the differences in method of extracting the sugar.

The pulp that remains in the diffusion batteries after washing out the sugar from the sliced beets forms an important by-product which is also used for feeding cattle. If there is a large cattle farm or ranch near the sugar factory, the wet pulp can be fed out just as it is emptied from the diffusion cells. The farmers who supply a sugar factory with beets frequently stipulate for a return of the beet pulp for feeding purposes, and a considerable amount of the pressed pulp is sent out from the sugar factories in freight cars, frequently to a distance of 50 or even 100 miles.

When local conditions are unfavorable for feeding the pulp or converting it into ensilage, many factories dry the pulp, using for this purpose the heat of the flue gas escaping from the boilers. The dried beet residue consists of a crisp brittle material which is packed in bags and sold as a cattle food; it is much relished by farm animals.

In the cane sugar industry a large amount of waste cellular matter also results from the harvesting and milling of the crop. The leafy portion of the cane top is sometimes fed to farm animals. In Louisiana, owing to the limited period of harvest and the haste to get the cane all pressed before winter, no time is available for utilizing the cane tops; they are therefore left upon the ground and are afterwards burned.

The bagasse, or cellular matter of the cane stalk, which is left after milling, is a very important by-product and many schemes have been proposed for its utilization. In most cane-producing countries the bagasse is used as a fuel to supply steam for the engines and heat for the evaporators. In many places the bagasse is the only supply of fuel available, and when this is the case other methods of utilization are impracticable. Bagasse, as it leaves the cane mill under good systems of extraction, contains about 50 per cent moisture and in this condition has a fuel value about one quarter that of soft coal. The employment of bagasse as fuel has appeared to many a very wasteful procedure, and attempts have been made to use it in the manufacture of paper.

Under good conditions of manufacture, four tons of wet bagasse will give one ton of paper.

In this connection mention should be made of a new process which is being tried at present, which, if successful, promises to revolutionize present methods of sugar manufacture. This process consists in shredding the cane near the fields where it is cut, drying the shredded stalks, pressing the sub-

stance into compact bales, and shipping it to factories in the United States or elsewhere. The dry material is there extracted with water in diffusion batteries, and the sugar which is washed out is manufactured directly into refined sugar. The residue of fiber, in another department of the same factory, is made into paper. The sugar world is watching the developments of this new experiment with great interest.

Utilization of Impurities removed in Clarification

The quantity of filter-press cake obtained in sugar manufacture varies greatly according to the amount of lime and other agents used in clarification, and according to the purity of the juices. The amount of wet press-cake obtained in Java by the ordinary process of clarification was found to be about 1 per cent of the weight of cane; the press-cake contained about 70 per cent of moisture and 10 per cent of sucrose, whence the actual amount of impurities removed from the juice is only about 0.2 per cent of the weight of the cane. The material consists of fine particles of bagasse ground off in milling, with an admixture of wax, proteins, gums, calcium sulphate and phosphate, iron oxide, and alumina, and considerable earthy matter which was brought in on the cane stalks from the field.

Where the carbonatation process of clarification is used, as is the case with beet-sugar manufacture, the press-cake is mostly calcium carbonate, the remainder consisting of the wax, proteins, gums, etc., found in the ordinary press-cake.

Great benefit has been derived from the use of filter-press cake as a fertilizer, the nitrogen existing in a form which is readily available. The excess of calcium carbonate in carbonatation cake has also been found beneficial upon certain soils.

Utilization of Waste Molasses

The word molasses has many shades of meaning; chemically speaking, we may consider it as the sugar factory mother liquor from which a part of the sucrose has been crystallized. The molasses from the first crystallization may yield, upon evaporation, a second crop of sugar crystals, and the molasses from this may even yield a small amount of impure third sugar. The approximate average composition of beet and cane molasses, from which no more sucrose will crystallize, is given in the following table:

	BEET MOLASSES	CANE MOLASSES
Water	20 %	20 %
Sucrose	50	30
Invert sugar	Trace	30
Salts	10 (5 % K_2O)	8 (4 % K_2O)
Nitrogenous substances	10 (2 % N)	2 (0.4 % N)
Gums, acids, etc.	10	10
	100	100

It is seen from the table that beet molasses is distinguished from cane molasses by a higher percentage of sucrose, by a much higher percentage of nitrogenous substances, and by a comparative absence of invert sugar.

The table shows 5 per cent of potash and 2 per cent of nitrogen in beet molasses and 4 per cent of potash and 0.4 per cent of nitrogen in cane molasses; these figures suggest at once that molasses might have some value as a fertilizer; and such in fact has been demonstrated to be the case upon certain kinds of soil, more especially those deficient in humus. The application of molasses to other soils, however, has caused an acid fermentation with souring of the soil and loss of fertility, so that this method of utilizing molasses is not uniformly successful. But the greatest objection against this use of molasses is its wastefulness. There are more profitable methods of using the sugar and other organic solids of molasses than employing them as a supply of humus.

A second use for molasses is as a fuel. Molasses containing 20 per cent moisture has a thermal value about three eighths that of coal. By means of specially constructed furnaces it is possible to secure a perfect combustion of the carbonaceous matter of molasses, 8 lb. of molasses supplying the same heat as 3 lb. of coal. A residue of ash, very rich in potash, is left, and this can find a use either as fertilizer or as a raw material for making potash salts.

Molasses, as we have seen, contains 50 per cent or more of sugar, and the use of such a valuable food material as a fuel is wasteful if other more profitable means of its disposal are available. Unquestionably the most perfect utilization of molasses is as a food. The odor of beet molasses is enough to convince one that it is unfit for human consumption. Waste cane molasses is much more palatable¹ . . . and its use as a stock food, whether for working animals, for milk production, or for fattening, is attended with splendid

¹ For discussion of molasses as human food see later sections of this chapter.

results, provided overfeeding, which might cause derangement of the digestive system, is avoided. The higher percentage of salts in beet molasses renders it somewhat less desirable as a cattle food than cane molasses.

The stable manure from animals fed upon molasses contains the valuable potash and nitrogen of the latter, and the use of such manure as a fertilizer has all the advantages and none of the disadvantages which result from the direct application of molasses to the soil.

From the sugar manufacturer's viewpoint, the dried leaves and pulp of the sugar beet and the bagasse of the sugar cane make most excellent and convenient materials for preparing molasses feeds. By combining them with molasses in suitable proportions a successful utilization of two by-products is accomplished in one operation. The percentage of molasses in mixed molasses feeds, according to analyses by Halligan, varies from 10 to 60 per cent. If more than 25 per cent of molasses is used, the feed must be heated in driers to remove the excess of moisture, which should not exceed 12 per cent. If too much moisture is present, the feed becomes sticky and is very liable to spoil through fermentation.

One of the most common methods of using molasses is the manufacture of alcohol and rum. In many tropical countries the sugar house and distillery are side by side, and the chemist is required to have a practical knowledge of fermentation and distilling as well as of sugar manufacture.

In manufacturing alcohol from molasses, the latter is first diluted to a sugar content of about 12 per cent. This solution, or "wash," is usually acidified slightly with sulphuric acid to prevent the growth of injurious bacteria, and then, after adding yeast, is fermented until no further decrease in density is observed. The fermented liquid is then distilled and the alcohol or rum collected in receivers.

Two gallons of cane molasses should give a yield of one gallon 180-proof alcohol (90 per cent strength) which is the usual standard for denaturing. Such alcohol, according to the last quotations, has a commercial value of 38 c. per gallon. The cost of manufacture may be set at 8 c. a gallon, which leaves 30 c. as the value of the raw molasses, or 15 c. per gallon. Sugar-cane molasses in tank cars, according to the last New Orleans quotations, has a commercial value of 6 c. a gallon, so that there is a profit of about 9 c. a gallon in operating a molasses distillery, provided the output of denatured alcohol finds a ready market, which at present is not always the case. The present high price of denatured alcohol prevents its competing with gasoline, and other petroleum products, as a source of power, light, or fuel.

In tropical countries the distiller of molasses must turn his attention almost entirely to the manufacture of rum.

Although we may not advocate its use as a beverage, rum is a commercial

product which the food chemist is called upon to inspect, analyze, and in other ways to reckon with. A few words may therefore be devoted to the methods peculiar to rum manufacture. Rum is valued not simply by its alcohol content but also by its flavor.

The flavor of rum is due to the presence of alcoholic esters of acetic, butyric, and other higher fatty acids; the first requirement in the production of flavor is the formation of the acids for esterification.

Acetic acid is prepared by allowing cane juice, skimmings from the clarifiers of the sugar house, and other refuse, to undergo an alcoholic fermentation, and then pumping the liquid on to cane trash in cisterns. An acetic fermentation sets in, just as when cider is poured over shavings in the quick vinegar process, and the solution becomes strongly acid.

For the production of butyric, caprylic, and the other fatty acids, a putrefactive fermentation is necessary, and this is carried out by dumping the dead yeast from the stills, cane refuse, lees from the retorts, and other adventitious matter, into a receptacle called the "muck hole." A putrefactive fermentation sets in with formation of butyric and other fatty acids. To neutralize the excess of free acid, which would retard fermentation, powdered marl is added from time to time. When the liquid in the muck hole is ripe, it is added to the acid cisterns, the free acetic acid thus liberating the butyric and other acids from their lime salts. The mixture of acids, thus produced, constitutes the basis for flavor production.

In conducting the fermentation, the wash is prepared by mixing molasses, skimmings, and cane juice with a certain amount of "dunder," which is the spent liquor obtained from the stills after distillation. The dunder is rich in nitrogenous compounds and salts, and serves as a nutrient for the growth of the yeast. After fermentation has begun, a requisite amount of the acid flavoring mixture is added; a part of the alcohol, formed by the action of the yeast upon the sugars, unites with the acids of the flavor to produce ethyl acetate, ethyl propionate, ethyl butyrate, and the other higher esters, all of which, passing over with the alcohol when the wash is distilled, give the resulting rum its characteristic aroma and flavor. High flavored Jamaica rum may contain as high as 1 or 2 per cent of esters, while the low flavored rums contain less than half of this amount. Over 95 per cent of the esters consists of ethyl acetate; the remainder is principally ethyl butyrate, the ester of chief importance as regards flavor production, with small amounts of other fatty acid homologues.

Methods for utilizing sugar beet molasses. Germany has made the greatest advancement in this regard. Of a total production of 400,000 tons of beet molasses in Germany, about 55 per cent is desaccharified for sugar production, about 30 per cent is used as a cattle food, about 10 per cent is fermented into

alcohol, and the remaining 5 per cent is utilized in various miscellaneous ways. Among the latter we may mention the use of molasses for manufacturing dye stuffs, shoe blacking, yeast, molds and briquettes, and numerous other commodities.

The residues from the desaccharification factories,¹ best known under its German name of molasses *schlempe*, has been a subject of special study from the standpoint of utilization. If we subtract the sucrose from the composition of beet molasses given in the previous table, we shall form a fair idea of the composition of *schlempe*. From 1000 kg. of beet molasses are obtained about 350 kg. of concentrated *schlempe*, containing about 30 per cent of mineral matter, mostly potash salts, some 20 per cent or more of nitrogenous substances, and a remainder of acids, gums, caramelization products, and other organic residues.

Molasses *schlempe* contains 12 to 15 per cent of potassium and 4 per cent or more of nitrogen, and its conversion into derivatives of these elements constitutes at present the chief method of utilization. The *schlempe* is first heated in retorts, by which means it is decomposed into a mixture of volatile products consisting of carbon dioxide, carbon monoxide, hydrogen, nitrogen, methane, ammonia, methyl amine, methyl alcohol, water, and other substances. The volatile decomposition products escape from the retorts at a temperature of about 400° C. and are led through a system of tubes heated to a temperature of about 1000° C. The effect of this heating is to convert the volatile nitrogenous compounds into ammonium cyanide. After leaving the hot tubes, the gases, which are always kept under reduced pressure, are cooled, freed from tar, and then washed over sulphuric acid to break up the ammonium cyanide, the ammonium sulphate, which is formed, being recovered. The hydrocyanic acid is then absorbed in water and the residue of combustible gases is led back to the furnaces for heating the retorts. The hydrocyanic acid is then distilled and absorbed in sodium hydroxide; the solution of the latter, after evaporating and crystallizing, yields solid sodium cyanide.

By the above method about three fourths of the nitrogen in molasses *schlempe* is recovered as ammonium sulphate and sodium cyanide, the remaining one fourth escaping as gaseous nitrogen. A small amount of pyridine is also obtained by this process, in connection with the ammonia. The residue of mineral matter in the retorts, after distilling the *schlempe*, is worked up into potash, of which some 15,000 tons are made annually in Germany from this source.

¹The desaccharification of beet molasses is accomplished by precipitating the sucrose as strontium saccharate, which, after separation from the molasses, is decomposed by carbon dioxide and the sucrose recovered as commercial sugar.

Two factories in Germany produce annually, by the process of distillation described, about 5000 tons of ammonium sulphate and 5000 tons of sodium cyanide, with a commercial value of about \$1,750,000. The sodium cyanide thus manufactured is nearly all exported to the Transvaal, where it is used for extracting gold by the well-known cyanide process.

Chemists in Germany are making further efforts towards improving the utilization of molasses *schlempe*. By the present methods of distillation about one fourth of the nitrogen is lost, and this is wasteful from the standpoint of highest economy. It has been felt by some chemists that efforts should be made towards removing some of the valuable organic constituents of the *schlempe* before making the distillation. Among the more important of the nitrogenous organic substances we may mention 10 to 12 per cent of betaine, 5 to 7 per cent of glutamic acid, 1 to 2 per cent of leucin and isoleucin, and various other amino-acids, etc. Search is being made for uses to which these substances may be put, and with the discovery of such uses we may look for greater refinements in the processes of utilization.

Molasses, Sirups, Honey

Molasses was formerly the mother liquor remaining after the removal of one crop of sugar crystals from the boiled-down juice of the sugar cane. Since the removal of cane sugar by one crystallization is far from complete, the molasses thus obtained was rich in sucrose and contained also much the greater part of the other constituents of the cane juice. Atwater and Bryant, in 1896, report the average of (12) American analyses published before that date as follows:

	PER CENT
Water	25.7
"Protein" (Nitrogen $\times$ 6.25)	2.7
Carbohydrates	68.0
Ash	3.6

The introduction of modern methods into sugar house practice has tended steadily to remove the sucrose more and more completely, with the result that the amount of molasses is decreased, its sugar content is lowered, and its content of impurities is increased. The term "impurities" is somewhat misleading, since the constituents other than sucrose which cane

juice naturally contains are unquestionably of food value; in fact, the molasses is a much less one-sided food than the sugar removed from it. When, however, the ash constituents and amids (or other "nitrogenous extractives") of the cane juice are concentrated to such an extent as in the final molasses of a modern raw sugar factory, the product is too strong in flavor to be attractive as human food, and may contain such a high concentration of salts as to throw doubt upon its wholesomeness when eaten in any considerable quantity. To illustrate the difference in composition between molasses from successive crystallizations of sugar Wiley gives the following typical analyses of "first," "second," and "third" molasses, the composition being reduced to a uniform basis of water content:

TABLE 51. COMPOSITION OF FIRST, SECOND, AND THIRD MOLASSES (WILEY)

	FIRST MOLASSES	SECOND MOLASSES	THIRD MOLASSES
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Water	20.00	20.00	20.00
Sucrose (cane sugar)	53.60	41.70	31.70
Dextrose (glucose)	8.76	12.20	15.00
Levulose (fructose)	8.00	12.50	16.50
Acids and gums	4.50	6.50	8.20
Proteins	0.20	0.25	0.30
Amids	0.94	1.50	2.00
Ash	4.00	5.35	6.30

According to the definitions and standards of the Association of Official Agricultural Chemists: *Molasses* is the product left after separating the sugar from *masse cuite*, *melada*, *mush sugar*, or *concrete*, and contains not more than 25 per cent of water and not more than 5 per cent of ash.

This standard would practically confine the term molasses as a commercial designation for human food to material of the nature of the "first molasses" of modern sugar manufacture.

Refiner's sirup is, as already explained, the "mother liquor" or residual liquid product obtained in the process of refining raw sugar. According to the standards of the Official Agricultural Chemists, it contains not more than 25 per cent of water and not more than 8 per cent of ash.

This product is also called "sugar refinery molasses" and sometimes "sugar-house molasses." The latter expression is ambiguous since the term "sugar house" is more commonly applied to the raw sugar factory than to the refinery.

Mixed sirups. Refiner's sirup contains the coloring and flavoring substances which distinguish the brown or yellow raw cane sugar from the white refined sugar (which latter, as it appears in commerce, may have been made either from the cane or the beet). The characteristic flavor of the raw cane sugar which is thus left in the sirup in the refining process is preferred by many people to the mere sweetness of sucrose or glucose. Hence the refiner's sirup is in demand for mixing with commercial glucose sirup (made from corn as described in an earlier chapter) for the production of "corn sirup with cane flavor" of which it is estimated that about 350,000,000 pounds are consumed annually in the United States.

Other mixed sirups are made from commercial glucose or corn sirup with refined cane sugar sirup (the product in this case being practically colorless), with sorghum sirup made by boiling down the juice of the sorghum cane, or with sirups made by concentrating the juice of the sugar cane without removing any of the sugar. More expensive mixed sirups are those made by mixing either glucose or sucrose sirup with maple sirup.

Maple sirup is the most highly prized of all table sirups. It is made by evaporating the sap of the sugar maple to such a point that the product contains only about 30 per cent of water. The standards of the Association of Official Agricultural Chemists specify that maple sirup shall contain not more than 32 per cent

of water and not less than 0.45 per cent of maple sugar ash. The reason for setting a minimum limit for ash in this case, whereas in the case of molasses and refiner's sirup the limit is set in the other direction, is that the maple sirup is prized for the flavor imparted by its "impurities" (constituents other than sugar), and there is no likelihood that the maple sap will be subjected to any such refining processes as might introduce an excessive amount of ash constituents, whereas a low ash content would be an indication that the maple sirup had been "extended" by diluting with a solution of refined sugar (a not uncommon method of adulteration, since refined cane sugar is much cheaper than unrefined maple sugar or even than the concentrated maple sap).

The census returns show 4,106,418 gallons or about 40,000,000 pounds of maple sirup, and 14,000,000 pounds of maple sugar made in the United States in 1909.

Open kettle cane sirup, made by boiling down in open vessels the juice of the sugar cane to a consistency similar to that of molasses, is said ¹ to be a common article of food in the Southern States. The product contains all the sugars and ash constituents of the cane juice, and their relative proportions are changed only in so far as the sucrose is in part hydrolyzed to glucose and fructose, and in part caramelized, giving the sirup a reddish tint.

Honey. Before sugar became a common article of commerce, honey was the chief sweetening material in use. Honey consists chiefly of a mixture of sugars gathered from flowers and more or less changed by the honeybee. It is the only common food material which contains more fructose than glucose. The average of 92 analyses of normal honeys ² shows:

¹ Wiley's *Foods and Their Adulteration*.

² Browne, United States Department of Agriculture, Bureau of Chemistry, Bulletin 110.

	PER CENT
Water	17.70
Sucrose	1.90
Fructose (levulose)	40.50
Glucose (dextrose)	34.48
Dextrin	1.51
Ash	0.18
Undetermined	3.73

In some instances genuine honey has been found to contain as high as 8 per cent of sucrose; more than that would usually be taken as an indication that the honey is either abnormal or adulterated. The differences in flavor are largely due to the characteristic esters ("ethereal" substances) found in the nectars of different flowers.

With the production of sucrose and glucose on a large scale and at a low price, honey has become relatively a luxury, and, except as prevented by legislation, has been largely adulterated with sucrose and glucose sirups. These adulterations are readily detected by chemical analysis, since genuine honey almost always contains enough fructose (levulose) to make it levo-rotatory to polarized light, whereas both sucrose and commercial glucose are dextro-rotatory. Adulteration of honey with "invert sugar," a mixture of equal parts glucose (dextrose) and fructose (levulose) obtained by hydrolysis of sucrose, is much more difficult of detection, since the main constituents of the honey and the adulterant are here the same.

Confectionery

The term confectionery covers a variety of products, all artificial or manufactured, consisting largely of sugar of some kind, with flavoring and usually also coloring material either added or developed by cooking processes.

Under the terms of the Food and Drugs Act confectionery is adulterated "if it contain terra alba, barytes, talc, chrome yellow, or other mineral substance or poisonous color or flavor,

or other ingredient deleterious or detrimental to health, or any vinous, malt, or spirituous liquor or compound or narcotic drug." Since adulterated foods are illegal even if truthfully branded, the above provision amounts to a specific prohibition against the use in confectionery of any one of the substances named. It is of interest to note the prohibition of alcohol in confectionery, whereas in ordinary foods and drinks its presence and amount are not restricted, and in the case of drugs it is only required that the proportion present be stated on the label. In addition to these special provisions, the purity of confectionery is further protected by all the general provisions of the law against adulteration and misbranding of food, since the term food as used in the law is defined as including "all articles used for food, drink, confectionery, or condiment."

Since all confections are artificial products, there is no natural guide to the establishment of any direct standards of food value, and as yet no standards other than those intended to exclude deleterious substances have been established.

Methods of making the different types of candies and other confections do not come within the scope of this work. The manufacture of the sugars, sucrose and commercial glucose, which are the chief ingredients of confectionery, has already been discussed. Perhaps the only other ingredient which is commonly used in confectionery in sufficient quantity to have a significant bearing upon the food value of the product is chocolate.

Chocolate is made from the cocoa bean, the seed of *Theobroma cacao*, a tree native to Central America and grown only in tropical regions. The seeds are borne in large pulpy fruit, each about 10 inches long and 4 inches thick and containing 20 to 40 seeds. At the proper stage of maturity, the fruit is cut from the tree, split open, and the seeds (cocoa beans) removed. These seeds are sometimes dried at once in the sun, but for the production of a better-flavored product are commonly first allowed to undergo a fermentation process. After drying in the sun,

the beans are roasted in revolving steel cylinders, after which the hulls are removed by machinery. The beans are then crushed and freed from the germs. The roasted and coarsely crushed product freed from hulls and germs is known as *cocoa nibs*. The nibs are thoroughly ground in stone mills, the material being reduced to a thin paste which on cooling sets to a hard cake. This is known as unsweetened or plain chocolate and has approximately the composition:

	PER CENT
Water	3
Protein	12
Theobromine	1
Fat	50
Fiber	3
Carbohydrates (other than fiber)	28
Ash	3

About one half of the fat contained in plain chocolate can be removed by pressing.

The fat thus obtained is a soft solid at ordinary temperatures and is known as *cocoa butter*.

Breakfast cocoa is obtained by grinding to an exceedingly fine powder the residue from which more or less of the cocoa butter has been expressed.

In confectionery sweetened chocolate is often mixed with cocoa butter, especially when a glossy chocolate covering for candies is desired.

According to the **definitions and standards** formulated by the Association of Official Agricultural Chemists, and more recently (Food Inspection Decision 136, June 1911) indorsed by the Board of Food and Drug Inspection, the names "*chocolate*," "*plain chocolate*," "*bitter chocolate*," "*chocolate liquor*," and "*bitter chocolate coatings*" are applied to the solid or plastic mass obtained by grinding cocoa nibs without removal of fat or other constituents except the germ, containing not more than 3 per cent of ash insoluble in water, 3.50 per cent of crude fiber and 9 per cent of starch, and not less than 45 per cent of cocoa fat.

"*Sweet chocolate*" and "*sweet chocolate coatings*" are terms applied to chocolate mixed with sugar (sucrose), with or without the addition of cocoa butter, spices, or other flavoring materials, and contain in the sugar and fat-free residue no higher percentage of either ash, fiber, or starch than is found in the sugar and fat-free residue of chocolate.

Cocoa and *powdered cocoa* are terms applied to cocoa nibs, with or without the germ, deprived of a portion of its fat and finely pulverized, and contain percentages of ash, crude fiber, and starch corresponding to those in chocolate after correction for fat removed.

Sweet cocoa and *sweetened cocoa* are terms applied to cocoa mixed with sugar (sucrose), and contain not more than 60 per cent of sugar (sucrose), and in the sugar and fat-free residue no higher percentage of either ash, crude fiber, or starch than is found in the sugar and fat-free residue of chocolate.

Cocoa nibs and *cracked cocoa* are the roasted broken seeds of the cacao tree freed from shell or husk.

Milk chocolate and *milk cocoa*, in the opinion of the Board, should contain not less than 12 per cent of milk solids, and the so-called nut chocolates should contain substantial quantities of nuts. If sugar is added, for example, to milk chocolate, it should be labeled "sweet milk chocolate," "sweet nut chocolate," etc.

When cocoa is treated with an alkali or an alkaline salt, as in the so-called Dutch process, and the finished cocoa contains increased mineral matter as the result of this treatment, but no alkali as such is present, the label should bear a statement to the effect that the cocoa contains added mineral ingredients, stating the amount. Cocoas and chocolates containing an appreciable amount of free alkali are adulterated. In the opinion of the Board, cocoa not treated with alkali is not soluble in the ordinary acceptance of the term and after treatment with alkali shows essentially the same lack of solubility. To designate the alkali-treated cocoa as "soluble" cocoa is therefore held to be misleading and deceptive.

The manufacture of confectionery has become an industry of considerable magnitude. According to the Census of Manufactures the wholesale value of confectionery made in manufacturing establishments in the United States in 1909 was \$134-796,000. Manufacturers of corn sirup estimate the annual production of candy in the United States at about 800,000,000 pounds and the amount of corn sirup or commercial glucose used in making this candy at about 200,000,000 pounds.

The average composition of miscellaneous sugars, starches, and confectionery as estimated by Atwater and Bryant is shown in Table 52. The fuel values have been recalculated by the use of the modern factors as already explained.

TABLE 52. AVERAGE COMPOSITION OF SUGARS, STARCHES, ETC.

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
SUGARS, STARCHES, ETC.									
Candy	—	—	—	—	—	96.0	—	—	1743
Honey	17	—	18.2	.4	—	81.2	—	.2	1480
Molasses, cane	15	—	25.1	2.4	—	69.3	—	3.2	1300
Starch, arrowroot . . .	1	—	2.3	—	—	97.5	—	.2	1770
Starch, cornstarch . . .	—	—	—	—	—	90.0	—	—	1635
Starch, manioca	1	—	10.5	.5	.1	88.8	—	.1	1625
Starch, tapioca	7	—	11.4	.4	.1	88.0	(6).1	.1	1608
Sugar, coffee or brown sugar	328	—	—	—	—	95.0	—	—	1723
Sugar, granulated . . .	—	—	—	—	—	100.0	—	—	1814
Sugar, maple ¹	—	—	5.0	—	—	93.0	—	—	1685
Sugar, powdered	—	—	—	—	—	100.0	—	—	1814
Sirup, maple ¹	—	—	34.2	—	—	64.0	—	—	1160
Chocolate	2	—	5.9	12.9	48.7	30.3	—	2.2	2772
Cocoa	3	—	4.6	21.6	28.9	37.7	—	7.2	2256

¹ Data from Snell.

Place of Sugars in the Diet

Dogmatic statements regarding the proper place of sugars in the diet are apt to be seriously misleading. The problem is complicated and the evidence in many respects is still obscure.

Until relatively recent times sugar was too expensive to be used freely by most people but with the development of the industry and the cheapening of the product the consumption of sugar has increased at an exceedingly rapid rate.

The thoughtful student of food problems must regard this development with mixed emotions. The cheapening of a staple article of food, which is almost universally popular and which, like the refined sugar of commerce, is of uniform and well-known composition and practically free from danger of adulteration or harmful deterioration, would be a source of great satisfaction but for the fact that refined sugar constitutes an extreme case of a one-sided food, its sole nutritive function being to serve as fuel so that, as the energy requirement of the body is met to a larger and larger extent by the consumption of refined sugar there is a constantly increasing danger of unbalancing the diet and making it deficient in some of the substances which are needed for the building and repair of body tissue and for the regulation of physiological processes.

The fuel value of sugar is about 1800 Calories per pound, so if as estimated the consumption of sugar in the United States now amounts to 85 pounds per capita per year, the energy obtained from eating sugar must amount to about 420 Calories per capita per day. If the per capita energy requirement be estimated at about 2000 Calories per day ¹ it follows that about

¹ If 3000 and 2400 Calories per day be accepted as the average requirements of working men and women respectively, it seems probable that the per capita requirement of the entire population, of which 20.5 per cent are below 15 years of age, will not exceed 2000 Calories per day.

one fifth of the energy requirement is being met by eating sugar (of course not all of this sugar appears on the table as such) and that the intake of protein, phosphorus, calcium, potassium, iron, and other essential elements, and of such important though imperfectly understood substances as the lipoids and vitamins is on the whole about one tenth lower than would be the case if the sugar were reduced one half and the energy now derived from sugar were supplied by an increased consumption of the other articles of food. Are we to assume that the ordinary dietary of the people of the United States furnishes such an abundance of all the essential elements and each specific necessary compound that a difference of 10 per cent in the intake is of no consequence? The investigations of recent years indicate clearly that no such assumption is justified. As regards some of the elements such as calcium and phosphorus there is very little margin of safety in the majority of American diets. From this standpoint it would be an improvement if without other change in dietary habits the sugar consumption were reduced, say to one half the present rate, and the same amount of energy obtained by increasing the consumption of other food materials.

It is doubtful whether in any other country the increase in consumption of refined sugar during the past two or three generations has been so rapid as in the United States. The present per capita consumption of sugar in several of the chief countries of the world is given by Browne as follows:

	POUNDS
England	95
United States	85
Germany	49
France	43
Austria	28
Russia	24
Turkey	20
Spain	16
Italy	11

It will be seen that the per capita consumption of sugar in continental Europe is not over half that in the United States. England reports a larger per capita consumption but it is to be noted that these statistics include both the sugar eaten as such and that used in the preparation of manufactured foods. Since England exports large amounts of jam, marmalade, and other food products containing much added sugar, it may be doubted whether the actual per capita consumption of sugar is any larger in England than in the United States.

The objection to the too free use of sugar, on the ground that it serves only as fuel and may replace to an undue extent other food materials which meet other nutritive requirements, applies equally to commercial glucose and to most candy. It does not hold to the same extent as regards molasses and those sirups which contain the natural ash constituents of the plant juices. Probably the most desirable of all materials with which to satisfy a desire for sweet-tasting foods are the fruits several of which contain from 10 to 15 per cent of sugars in the fresh state and from 50 to 75 per cent when dried. Some of the advantageous characteristics of fruit as food have been discussed in Chapter IX.

In addition to the question to what extent sugar may be allowed to displace other foods without danger of making the diet one-sided, there are several other considerations which should be kept in mind in attempting to assign to sugar its proper place as a food.

Sucrose entering the blood as such is not utilized; only the products of digestion are normally absorbed into the body. The digestion of sugar is a relatively simple process since it involves only one hydrolysis. This digestive hydrolysis, however, is not effected until the sugar reaches the intestine. Hence nearly all the sugar eaten remains as such in the stomach unless it is decomposed there by the action of micro-organisms. Herter found that cane sugar is more apt to undergo fermentation in

the stomach than is milk sugar. The products yielded by the more common types of fermentation, of which lactic acid is perhaps the best example, are not in any ordinary sense poisonous but may be irritating when formed in large amount. Aside from the question of fermentation, sugar is often directly irritating to the stomach, for unless much diluted with other food or with water it is likely in some part of the stomach to furnish a sugar solution of sufficient concentration to result in a distinct abstraction of water from the mucous membrane. The effect of such abstraction of water from the mucous membrane on a small scale is easily observed by holding a piece of hard candy in one side of the mouth for some time without moving it. When the same action takes place on a much larger scale in the stomach and especially when, from frequent free use of sugar, it occurs repeatedly, some injury to the stomach must be anticipated.

The fact that sugar may have a disturbing influence upon digestion does not imply that the sugar itself is at all likely to escape digestion. The readiness with which sugar is hydrolyzed by the sugar-splitting enzyme of the intestinal juice combined with the susceptibility of sugar to the attack of bacteria makes it unlikely that much sugar will pass through the digestive tract unchanged. In a recent bulletin of the United States Department of Agriculture,¹ Mrs. Abel cites experiments in which 5 ounces of sugar per day, fed to healthy men as part of a simple mixed diet, showed an average digestibility of 98.9 per cent. According to the same authority 3 or 4 ounces per day "seem to be digested by the healthy adult without difficulty."

Athletes and farm laborers at hard work have in many instances been observed to take large quantities of sugar, often as lemonade or in admixture with other fruit juices, without any apparent ill effects. In such cases the sugar is employed to furnish the extra energy required for the muscular activity and so does not necessarily tend toward a sub-normal intake

¹ Farmers' Bulletin 535, June, 1913.

of the foods which are valuable for their ash constituents as well as their energy. In fact when the sugar is taken with fruit juices the consumption of the latter may thereby be increased.

The paragraphs which follow are taken from Mrs. Abel's general conclusions in the Government bulletin referred to above.

One may say in general that the wholesomeness of sweetened foods and their utilization by the system is largely a question of quantity and concentration. For instance, a simple pudding flavored with sugar rather than heavily sweetened is considered easy of digestion, but when more sugar is used, with the addition of eggs and fat, we have as the result highly concentrated forms of food, which can be eaten with advantage only in moderate quantities and which are entirely unsuited to children and invalids.

It is true that the harvester, lumberman, and others who do hard work in the open air consume great amounts of food containing considerable quantities of sugar, such as pie and doughnuts, and apparently with impunity; but it is equally true that people living an indoor life find that undue amounts of pie, cake, and pudding, with highly sweetened preserved fruit, and sugar in large amounts on cooked cereals, almost always bring indigestion sooner or later.

From a gastronomic point of view it would seem also that in the American cuisine sugar is used with too many kinds of food, with a consequent loss of variety and piquancy of flavor in the different dishes. The nutty flavor of grains and the natural taste of mild fruits are very often concealed by the addition of large quantities of sugar.

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CHAPTER XII

FOOD ADJUNCTS AND UNCLASSIFIED FOOD MATERIALS

MANY articles commonly classed as foods are consumed rather for their condimental properties than for nutritive value. In commerce and in food legislation there is usually no attempt to define the boundary between foods and condiments. Thus it will be remembered that the Food and Drugs Act so defines the word food as to cover all articles used as food, drink, confection, or condiment. Some of the condiments offer considerable opportunity for adulteration, and in the enforcement of the pure food laws this group of materials usually receives a large share of attention. Since condiments and other food adjuncts are with few exceptions not of great importance either economically or as factors in the food supply, no attempt will be made to discuss them here in the manner in which the different types of food have been discussed; only brief descriptive statements will be given and in many cases these will be limited to the official definition or standard, since interest centers in the question of adulteration.

Salt

Salt is prepared in many localities throughout the world, sometimes by mining rock salt, sometimes by pumping brine out of salt wells, sometimes by impounding the water of salt lakes or of the ocean and allowing it to evaporate in the sun, then refining the product by recrystallization.

In the United States, salt is produced chiefly by Michigan,

New York, Kansas, and Ohio, which together furnish about nine tenths of the total output.¹

According to Bailey most of the salts on the market contain from 97 to 99 per cent of sodium chloride.

In order to avoid the introduction of impurities which would alter the flavor, careful butter-makers pay much attention to the purity of the salt which they use, and thus the term "dairy salt" has come to signify as high a degree of purity as is usually attempted commercially. An analysis of high grade dairy salt has been given in the account of butter manufacture (page 371).

According to the standards of the Association of Official Agricultural Chemists: *Table salt, dairy salt*, is fine-grained crystalline salt containing, on a water-free basis, not more than 1.4 per cent of calcium sulphate, nor more than 0.5 per cent of calcium and magnesium chloride, nor more than 0.1 per cent of matters insoluble in water.

In order to prevent salt, which is to be exposed to atmospheric conditions on the table, from becoming caked through absorption of moisture, it is sometimes mixed with a small amount of starch or of calcium phosphate. In order to avoid conflict with the standard set by the Official Chemists, salt thus prepared should be labeled to show its nature and composition.

Spices

The spices owe their condimental properties most often, probably, to volatile oils, but also in several cases to other substances, as will be seen from the descriptions which follow. Adulteration of whole spice usually takes the form of abstracting a part of the valuable component, while ground spices are often adulterated by addition of ground hulls (or other fibrous material) or of starchy materials such as flour, and sometimes of mineral

¹ Bailey, International Congress of Applied Chemistry, 1903.

matter. Where standards have been adopted it will be seen that they usually set limits to one or more of these components.

Allspice, or pimento, is obtained from an evergreen tree, belonging to the same family with the clove, which is found in the West Indies and is cultivated chiefly in Jamaica.

The commercial spice is obtained by drying the berries, which, in order to avoid loss of aroma, are gathered when they have grown to full size but before they are fully ripe.

The average percentages of some constituents in samples of pure whole allspice analyzed by Winton, Mitchell, and Ogden at the Connecticut Experiment Station were as follows:

	PER CENT
Moisture	9.78
Total ash	4.47
Ash soluble in water	2.47
Ash insoluble in hydrochloric acid	0.03
Volatile oil	4.05
Nonvolatile oils and fats	5.84
Alcohol extract	11.79
Starch (by diastase method)	3.04
Crude fiber	22.39
Protein (Nitrogen $\times 6.25$)	5.75
Quercitannic acid	9.71

The volatile oil of allspice is similar to that of cloves and according to Leach is composed of *eugenol* ($C_{10}H_{12}O_2$) and a hydrocarbon belonging to the sesquiterpenes whose exact chemical constitution has not yet been determined.

According to the definition and standard of the Association of Official Agricultural Chemists: *Allspice*, *pimento*, is the dried fruit of the *Pimenta pimenta* (L.) Karst., and contains not less than 8 per cent of quercitannic acid, not more than 6 per cent of total ash, not more than 0.5 per cent of ash insoluble in hydrochloric acid, and not more than 25 per cent of crude fiber.

Anise is the fruit of the *Pimpinella anisum* L.

Bay leaf is the dried leaf of *Laurus nobilis* L.

Capers are the flower buds of a shrub, *Capparis spinosa* L., and are commonly pickled in vinegar.

Caraway is the fruit (so-called seed) of *Carum carui* L., an umbelliferous plant growing chiefly in the northern and central parts of Europe and Asia. The dry caraways yield 3 to 6 per cent of a volatile oil which is said to contain cymene, cymene aldehyde, carvone, and limonene.

Cassia is the dried bark of *Cinnamomum cassia* and some other species of the same genus. Its condimental properties are due to the volatile oil, which may be obtained as such in commerce under the name of oil of cassia, and of which the chief component is cinnamic aldehyde. *Cassia buds* are the dried immature buds of species of *Cinnamomum*.

Cayenne, or *cayenne pepper*, is the dried ripe fruit of *Capsicum frutescens*, *Capsicum baccatum*, or some other small fruited species of *capsicum*, and owes its pungency largely to the presence of a characteristic alkaloid *capsicine*.

Cinnamon in the stricter use of the term (true cinnamon) is the dried inner bark of *Cinnamomum zeylanicum* (Beyne). Commonly, however, the term cinnamon is applied to the dried bark of any species of *Cinnamomum* from which the outer layers may or may not have been removed. Cinnamon, like cassia, owes its characteristic properties to a volatile oil of which cinnamic aldehyde is the chief component.

Ground cinnamon or *ground cassia* is a powder consisting of cinnamon, cassia, cassia buds, or a mixture of these.

Cloves are the dried flower buds of the clove plant (*Caryophyllus aromaticus*, or *Eugenia caryophyllata*) which is an ever-green tree growing 20 to 40 feet high and cultivated largely in Brazil, Ceylon, India, Zanzibar, Mauritius, and the West Indies.

The average percentages of the more prominent constituents as found by Winton, Ogden, and Mitchell in analysis of eight samples of whole cloves of known purity were as follows:

	PER CENT
Moisture	7.81
Total ash	5.92
Ash soluble in water	3.58
Ash insoluble in hydrochloric acid	0.06
Volatile oil	19.18
Nonvolatile oils and fats	6.49
Alcohol extract	14.87
Starch (by diastase method)	2.74
Crude fiber	8.10
Protein (Nitrogen $\times 6.25$)	6.18
Quercitannic acid	18.19

The condimental property of cloves is chiefly due to the volatile oil, which consists mainly of eugenol with smaller quantities of a sesquiterpene known as caryophyllene. Probably however the fixed oils and resins and the tannin may also contribute to the characteristic pungency of the clove.

According to the standard of the Association of Official Agricultural Chemists cloves must contain not more than 5 per cent of clove stems, not less than 10 per cent of volatile oil, not less than 12 per cent of quercitannic acid, not more than 8 per cent of total ash, not more than 0.5 per cent of ash insoluble in hydrochloric acid, and not more than 10 per cent of crude fiber.

Coriander is the dried fruit of *Coriandrum sativum* L.

Cumin seed is the fruit of *Cuminum cyminum* L.

Dill seed is the fruit of *Anethum graveolens* L.

Fennel is the fruit of *Feniculum feniculum*.

Ginger is the rhizome or root-stock of *Zinziber officinale* or *Zinziber zinziber*, an annual plant growing 3 to 4 feet high, a native of India and China, now cultivated also in tropical America, Africa, and Australia.

The root is either washed or peeled (decorticated) then dried and sometimes bleached or sprinkled with carbonate of lime. Preserved ginger is prepared by boiling the root and then treating it with sugar or honey.

Ginger is distinguished by high starch content and by its volatile oil and its resinous matter. The latter is most abundant in the outer layers, and so is largely lost when the roots are peeled or decorticated.

Winton, Ogden, and Mitchell analyzed 18 samples of whole ginger representing both white and black varieties with the following results:

	MAXIMUM	MINIMUM	AVERAGE
Moisture	11.72	8.71	10.44
Total ash	9.35	3.61	5.27
Ash soluble in water	4.09	1.73	2.71
Ash insoluble in HCl	2.29	0.02	0.44
Lime (CaO)	3.53	0.20	0.80
Volatile oil	3.09	0.96	1.97
Nonvolatile oils and fats	5.42	2.82	4.10
Alcohol extract	6.58	3.63	5.18
Starch (by diastase method)	60.31	49.05	54.53
Crude fiber	5.50	2.37	3.91
"Protein" (Nitrogen $\times$ 6.25)	9.75	4.81	7.74
Cold water extract	17.55	10.92	13.42

According to the standards of the Official Agricultural Chemists, *ginger* must contain not less than 42 per cent of starch and not more than 8 per cent of crude fiber, 6 per cent of total ash, 1 per cent of lime, 3 per cent of ash insoluble in hydrochloric acid; while *limed* ("bleached") ginger must contain not over 4 per cent of lime or 10 per cent of total ash and in other respects should conform to the standard for ginger.

Horseradish is the root of *Roripa armoracia* either by itself or ground and mixed with vinegar.

Mace is prepared by drying the arillus which surrounds the nutmeg kernel. Mace contains notable quantities of fixed oils and of resinous matter. Its volatile oil resembles that of nutmeg. It contains a considerable amount of carbohydrate,

which behaves like starch in analysis but gives only a red reaction with iodine and is called an amyloextrin.

Four samples of pure Banda or Penang mace examined by Winton, Ogden, and Mitchell gave the following average results :

Moisture	11.05
Total ash	2.01
Ash soluble in water	1.13
Ash insoluble in hydrochloric acid	0.07
Volatile oil	7.58
Nonvolatile ether extract	22.48
Alcohol extract	23.11
Amyloextrin (as starch by diastase method)	27.87
Crude fiber	3.20
"Protein" (Nitrogen $\times$ 6.25)	6.47

According to the standard of the Association of Official Agricultural Chemists mace should contain between 20 and 30 per cent of nonvolatile ether extract and not more than 3 per cent of total ash, 0.5 per cent of ash insoluble in hydrochloric acid, or 10 per cent of crude fiber.

Marjoram is the leaf, flower, and branch of *Majorana majorana*.

Mustard seed is the seed of *Sinapis alba* (white mustard), *Brassica nigra* (black mustard), *Brassica juncea* (black or brown mustard). These are annual plants belonging to the family *Cruciferae*.

The seeds contain a considerable proportion of fatty oil of the same general character as rapeseed oil. In preparing the ground spice the seeds are crushed and the hulls are usually separated more or less completely. A part of the fatty oil is then pressed out and the residual *mustard cake* is broken up and reduced to a fine powder which is the *mustard flour* of commerce.

Winton and Mitchell made partial analyses of 18 samples of commercial mustards, believed to be pure, with the following results :

	MAXIMUM	MINIMUM	AVERAGE
	Per cent	Per cent	Per cent
Total ash	7.35	4.81	5.99
Volatile oil.	1.90	0.00	0.56
Nonvolatile ether extract	28.10	17.14	20.61
Starch (by diastase method)	2.08	0.28	1.07
Crude fiber	4.87	1.58	2.58
"Protein" (Nitrogen $\times$ 6.25)	43.56	35.63	39.57

While mustard seeds contain very little volatile oil as such, there are present substances which, under the influence of enzymes also present, readily undergo hydrolysis with formation of volatile oil.

Black mustard seed contains *sinigrin* (potassium myronate, $\text{KC}_{10}\text{H}_{16}\text{NS}_2\text{O}_9$), a glucoside which splits yielding glucose, potassium acid sulphate, and allyl isothiocyanate ($\text{C}_3\text{H}_5\text{CNS}$). The last named is called "*mustard oil*" and is a volatile oily liquid of very strong odor and capable of forming blisters when dropped on the skin.

White mustard contains a different glucoside, *sinalbin*, $\text{C}_{30}\text{H}_{42}\text{N}_2\text{S}_2\text{O}_{15}$. This substance undergoes hydrolysis in a manner analogous to sinigrin, and when thus hydrolyzed yields glucose, sinapin acid sulphate ($\text{C}_{16}\text{H}_{24}\text{NO}_5\text{HSO}_4$), and *sinalbin mustard oil* ($\text{C}_7\text{H}_7\text{ONCS}$). The latter resembles the volatile oil from black mustard (allyl isothiocyanate) in pungency.

According to the standards of the Association of Official Agricultural Chemists: *Ground mustard* is a powder made from mustard seed, with or without the removal of the hulls and a portion of the fixed oil, and contains not more than 2.5 per cent of starch and not more than 8 per cent of total ash; *prepared mustard*, *German mustard*, *French mustard*, *mustard paste*, is a mixture of ground mustard seed or mustard flour with salt, spices and vinegar, and contains in the material other than water,

fat, and salt, at least 35 per cent of protein and not over 12 per cent of crude fiber.

Nutmeg is the dried seed of the *Myristica fragrans*, a tree native to the Malay archipelago, which somewhat resembles the orange tree in appearance.

The nutmegs are prepared for commerce by drying, usually after washing in limewater, or are powdered with air-slaked lime after drying.

Winton, Ogden, and Mitchel analyzed 4 samples of nutmeg of known purity with the following maximum and minimum results:

	MAXIMUM	MINIMUM
	<i>Per cent</i>	<i>Per cent</i>
Moisture	10.83	5.79
Total ash	3.26	2.13
Ash soluble in water	1.46	0.82
Ash insoluble in hydrochloric acid	0.01	0.00
Volatile oil	6.94	2.56
Nonvolatile ether extract	36.04	28.73
Alcohol extract	17.38	10.42
Starch (by diastase method)	24.20	14.62
Crude fiber	3.72	2.38
"Protein" (Nitrogen $\times$ 6.25)	7.00	6.56

As standardized by the Association of Official Agricultural Chemists, nutmeg should contain not less than 25 per cent of nonvolatile ether extract, not more than 5 per cent of total ash nor more than 0.5 per cent of ash insoluble in hydrochloric acid, and not more than 10 per cent of crude fiber.

Paprika is the dried ripe fruit of *Capsicum annuum*, or some other large fruited species of *Capsicum*, excluding seeds and stems.

Pepper is the berry of a climbing plant (*Piper nigrum*) which is cultivated in tropical countries. *Black pepper* is ob-

tained by picking the berries while immature; *white pepper*, by allowing the berries to ripen and become more starchy. The condimental properties are attributed chiefly to the volatile oil, a hydrocarbon of the formula $C_{10}H_{16}$, and the nitrogenous bases piperidine and piperine. Piperine is extracted by ether and may be estimated approximately by multiplying the nitrogen of the nonvolatile ether extract by the factor 20.46.

Analyses by Winton, Ogden, and Mitchel, and by Winton and Bailey, covering 20 samples of black and 10 samples of white pepper, and representing the leading varieties imported into the United States, gave the following average results:

	BLACK PEPPER	WHITE PEPPER
	<i>Per cent</i>	<i>Per cent</i>
Moisture	11.86	13.47
Total ash	5.10	1.77
Ash soluble in water	2.60	0.47
Ash insoluble in HCl	0.70	0.10
Volatile oil	1.28	0.73
Nonvolatile ether extract	8.41	6.91
Alcohol extract	9.44	7.66
Starch (by diastase method)	33.28	56.47
Crude fiber	13.62	3.14
Total nitrogen	2.25	2.04
Nitrogen in nonvolatile ether extract	0.33	0.30
"Protein" (Nitrogen other than that of ether extract $\times 6.25$)	11.93	10.89

To meet the standards of the Association of Official Agricultural Chemists: *Black pepper* must contain not less than 6 per cent of nonvolatile ether extract, not less than 25 per cent of starch, not more than 7 per cent of total ash, not more than 2 per cent of ash insoluble in hydrochloric acid, and not more than 15 per cent of crude fiber, and 100 parts of the nonvolatile ether extract must contain not less than 3.25 parts of nitrogen;

white pepper must contain not less than 6 per cent of non-volatile ether extract, not less than 50 per cent of starch, not more than 4 per cent of total ash, not more than 0.5 per cent of ash insoluble in hydrochloric acid, and not more than 5 per cent of crude fiber, and 100 parts of nonvolatile ether extract must contain not less than 4 parts of nitrogen.

Saffron is the dried stigma of *Crocus sativus* L.

Sage is the leaf of *Salvia officinalis* L.

Savory, summer savory, is the leaf, blossom, and branch of *Satureja hortensis* L.

Thyme is the leaf and tip of blooming branches of *Thymus vulgaris* L.

Flavoring Extracts

A large number of flavoring extracts are available in the market, the extracts of vanilla and of lemon being most commonly used.

Vanilla extract is made from the vanilla bean, the fruit of a climbing vine, *Vanilla planifolia*, which belongs botanically to the orchids and is indigenous to tropical America. The vanilla beans grown in Mexico are considered the finest. When the pods turn brown they are gathered and allowed to undergo a process of fermentation which develops the characteristic aroma. The beans are then dried for market and the commercial extract is made by cutting them up and soaking them in alcohol, usually with addition of sugar. The odor of vanilla and vanilla extracts is due chiefly to vanillin ($C_8H_8O_3$).

Lemon extract is made by soaking lemon peel in strong alcohol and owes its flavor chiefly to the volatile oil of the lemon peel, of which the chief component is *citral* ($C_{10}H_{16}O$).

Adulteration of flavoring extracts usually takes the form either of substituting artificial or inferior substances or of making the extract unjustifiably dilute. The question of the proper concentration must necessarily be fixed somewhat arbi-

trarily. The limits fixed by the Association of Official Agricultural Chemists have usually been upheld by the courts.

The definitions and standards for flavoring extracts as adopted by that Association are as follows :

1. *A flavoring extract*¹ is a solution in ethyl alcohol of proper strength of the sapid and odorous principles derived from an aromatic plant, or parts of the plant, with or without its coloring matter, and conforms in name to the plant used in its preparation.

2. *Almond extract* is the flavoring extract prepared from oil of bitter almonds, free from hydrocyanic acid, and contains not less than one (1) per cent by volume of oil of bitter almonds.

2a. *Oil of bitter almonds*, commercial, is the volatile oil obtained from the seed of the bitter almond (*Amygdalus communis* L.), the apricot (*Prunus armeniaca* L.), or the peach (*Amygdalus persica* L.).

3. *Anise extract* is the flavoring extract prepared from oil of anise and contains not less than three (3) per cent by volume of oil of anise.

3a. *Oil of anise* is the volatile oil obtained from the anise seed.

4. *Celery seed extract* is the flavoring extract prepared from celery seed or the oil of celery seed, or both, and contains not less than three tenths (0.3) per cent by volume of oil of celery seed.

4a. *Oil of celery seed* is the volatile oil obtained from celery seed.

5. *Cassia extract* is the flavoring extract prepared from oil of cassia and contains not less than two (2) per cent by volume of oil of cassia.

5a. *Oil of cassia* is the lead-free volatile oil obtained from the leaves or bark of *Cinnamomum cassia* Bl., and contains not less than seventy-five (75) per cent by weight of cinnamic aldehyde.

6. *Cinnamon extract* is the flavoring extract prepared from

¹ The flavoring extracts herein described are intended solely for food purposes and are not to be confounded with similar preparations described in the Pharmacopœia for medicinal purposes.

oil of cinnamon, and contains not less than two (2) per cent by volume of oil of cinnamon.

6a. *Oil of cinnamon* is the lead-free volatile oil obtained from the bark of the Ceylon cinnamon (*Cinnamomum zeylanicum* Breyne), and contains not less than sixty-five (65) per cent by weight of cinnamic aldehyde and not more than ten (10) per cent by weight of eugenol.

7. *Clove extract* is the flavoring extract prepared from oil of cloves, and contains not less than two (2) per cent by volume of oil of cloves.

7a. *Oil of cloves* is the lead-free, volatile oil obtained from cloves.

8. *Ginger extract* is the flavoring extract prepared from ginger and contains in each one hundred (100) cubic centimeters, the alcohol-soluble matters from not less than twenty (20) grams of ginger.

9. *Lemon extract* is the flavoring extract prepared from oil of lemon, or from lemon peel, or both, and contains not less than five (5) per cent by volume of oil of lemon.

9a. *Oil of lemon* is the volatile oil obtained, by expression or alcoholic solution, from the fresh peel of the lemon (*Citrus limonum* L.), has an optical rotation (25° C.) of not less than + 60° in a 100-millimeter tube, and contains not less than four (4) per cent by weight of citral.

10. *Terpeneless extract of lemon* is the flavoring extract prepared by shaking oil of lemon with dilute alcohol, or by dissolving terpeneless oil of lemon in dilute alcohol, and contains not less, than two tenths (0.2) per cent by weight of citral derived from oil of lemon.

10a. *Terpeneless oil of lemon* is oil of lemon from which all or nearly all of the terpenes have been removed.

11. *Nutmeg extract* is the flavoring extract prepared from oil of nutmeg, and contains not less than two (2) per cent by volume of oil of nutmeg.

11a. *Oil of nutmeg* is the volatile oil obtained from nutmegs.

12. *Orange extract* is the flavoring extract prepared from oil of orange, or from orange peel, or both, and contains not less than five (5) per cent by volume of oil of orange.

12a. *Oil of orange* is the volatile oil obtained, by expression or alcoholic solution, from the fresh peel of the orange (*Citrus aurantium* L.) and has an optical rotation (25° C.) of not less than $+95^{\circ}$ in a 100-millimeter tube.

13. *Terpeneless extract of orange* is the flavoring extract prepared by shaking oil of orange with dilute alcohol, or by dissolving terpeneless oil of orange in dilute alcohol, and corresponds in flavoring strength to orange extract.

13a. *Terpeneless oil of orange* is oil of orange from which all or nearly all of the terpenes have been removed.

14. *Peppermint extract* is the flavoring extract prepared from oil of peppermint, or from peppermint, or both, and contains not less than three (3) per cent by volume of oil of peppermint.

14a. *Peppermint* is the leaves and flowering tops of *Mentha piperita* L.

14b. *Oil of peppermint* is the volatile oil obtained from peppermint and contains not less than fifty (50) per cent by weight of menthol.

15. *Rose extract* is the flavoring extract prepared from otto of roses, with or without red rose petals, and contains not less than four tenths (0.4) per cent by volume of otto of roses.

15a. *Otto of roses* is the volatile oil obtained from the petals of *Rosa damascena* Mill., *R. centifolia* L., or *R. moschata* Herrm.

16. *Savory extract* is the flavoring extract prepared from oil of savory, or from savory, or both, and contains not less than thirty-five hundredths (0.35) per cent by volume of oil of savory.

16a. *Oil of savory* is the volatile oil obtained from savory.

17. *Spearmint extract* is the flavoring extract prepared from oil of spearmint, or from spearmint, or both, and contains not less than three (3) per cent by volume of oil of spearmint.

17a. *Spearmint* is the leaves and flowering tops of *Mentha spicata* L.

17b. *Oil of spearmint* is the volatile oil obtained from spearmint.

18. *Star anise extract* is the flavoring extract prepared from oil of star anise, and contains not less than three (3) per cent by volume of oil of star anise.

18a. *Oil of star anise* is the volatile oil distilled from the fruit of the star anise (*Illicium verum* Hook).

19. *Sweet basil extract* is the flavoring extract prepared from oil of sweet basil, or from sweet basil, or both, and contains not less than one tenth (0.1) per cent by volume of oil of sweet basil.

19a. *Sweet basil, basil*, is the leaves and tops of *Ocimum basilicum* L.

19b. *Oil of sweet basil* is the volatile oil obtained from basil.

20. *Sweet marjoram extract, marjoram extract*, is the flavoring extract prepared from the oil of marjoram, or from marjoram, or both, and contains not less than one (1) per cent by volume of oil of marjoram.

20a. *Oil of marjoram* is the volatile oil obtained from marjoram.

21. *Thyme extract* is the flavoring extract prepared from oil of thyme, or from thyme, or both, and contains not less than two tenths (0.2) per cent by volume of oil of thyme.

21a. *Oil of thyme* is the volatile oil obtained from thyme.

22. *Tonka extract* is the flavoring extract prepared from tonka bean, with or without sugar or glycerin, and contains not less than one tenth (0.1) per cent by weight of coumarin extracted from the tonka bean, together with a corresponding proportion of the other soluble matters thereof.

22a. *Tonka bean* is the seed of *Coumarouna odorata* Aublet (*Dipteryx odorata* (Aubl.) Willd.).

23. *Vanilla extract* is the flavoring extract prepared from vanilla bean, with or without sugar or glycerin, and contains in one hundred (100) cubic centimeters the soluble matters from not less than ten (10) grams of the vanilla bean.

23a. *Vanilla bean* is the dried, cured fruit of *Vanilla planifolia* Andrews.

24. *Wintergreen extract* is the flavoring extract prepared from oil of wintergreen, and contains not less than three (3) per cent by volume of oil of wintergreen.

24a. *Oil of wintergreen* is the volatile oil distilled from the leaves of the *Gaultheria procumbens* L.

Unclassified Food Materials

Soups containing both animal and vegetable substances, and a few other articles grouped as unclassified by Atwater and Bryant, are included in Table 53 which is taken from Atwater's and Bryant's tables except that the fuel values have been recalculated, as explained in previous chapters.

TABLE 53. COMPOSITION OF UNCLASSIFIED FOOD MATERIALS

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN (N $\times$ 6.25)	FAT	TOTAL CARBOHY- DRATES	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
<i>Soups, homemade</i>								
Beef soup	2	—	92.9	4.4	.4	1.1	1.2	116
Bean soup	1	—	84.3	3.2	1.4	9.4	1.7	286
Clam chowder	2	—	88.7	1.8	.8	6.7	2.0	187
Meat stew	5	—	84.5	4.6	4.3	5.5	1.1	359
<i>Soups, canned</i>								
Asparagus, cream of	1	—	87.4	2.5	3.2	5.5	1.4	276
Bouillon	3	—	96.6	2.2	.1	.2	.9	47
Celery, cream of	1	—	88.6	2.1	2.8	5.0	1.5	243
Chicken gumbo	2	—	89.2	3.8	.9	4.7	1.4	191
Chicken soup	2	—	93.8	3.6	.1	1.5	1.0	97
Consommé	1	—	96.0	2.5	—	.4	1.1	53

TABLE 53. COMPOSITION OF UNCLASSIFIED FOOD MATERIALS—Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN (N X 6.25)	FAT	TOTAL CARBOHYDRATES	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
<i>Soups, canned</i>								
Corn, cream of	1	—	86.8	2.5	1.9	7.8	1.0	265
Julienne	1	—	95.9	2.7	—	.5	.9	57
Mock turtle	2	—	80.8	5.2	.9	2.6	1.3	182
Mulligatawny	2	—	89.3	3.7	.1	5.7	1.2	175
Oxtail:								
Edible portion	2	—	88.8	4.0	1.3	4.3	1.6	204
As purchased	1	1.8	87.8	3.8	.5	4.2	1.9	166
Pea soup	4	—	86.9	3.6	.7	7.6	1.2	232
Pea, cream of green	1	—	87.7	2.6	2.7	5.7	1.3	261
Tomato soup	2	—	90.0	1.8	1.1	5.6	1.5	179
Turtle, green	1	—	86.6	6.1	1.9	3.9	1.5	259
Vegetable	1	—	95.7	2.9	—	.5	.9	62
<i>Miscellaneous</i>								
Mincemeat, commercial . . .	3	—	27.7	6.7	1.4	60.2	4.0	1271
Mincemeat, homemade . . .	3	—	54.4	4.8	6.7	32.1	2.0	943
Salad, ham, as purchased . .	1	—	69.4	15.4	7.6	5.6	2.0	691
Sandwich, egg, as purchased	1	—	41.4	9.6	12.7	34.5	1.8	1319
Sandwich, chicken, as purchased	1	—	48.5	12.3	5.4	32.1	1.7	1026
Cereal coffee infusion (1 part boiled in 20 parts water) ¹	5	—	98.2	0.2	1.4	—	0.2	29
Yeast, compressed, as purchased	1	—	65.1	11.7	21.0	—	1.8	610

¹ The average of five analyses of cereal coffee grain is: Water 6.2, protein 13.3, fat 3.4, carbohydrates 72.6, and ash 4.5 per cent. Only a portion of the nutrients, however, enter into the infusion. The average in the table represents the available nutrients in the cereal coffee infusion. Infusions of genuine coffee and of tea contain practically no nutrients.

Tea, Coffee, and Cocoa

These three materials so largely used in making beverages are alike in having a certain stimulating property due to alkaloid and so are often discussed together:

Tea consists of the prepared leaves and leaf buds of the tea bush belonging to different species of *Thea*, chiefly *Thea Chinensis*. The choicest teas are made from young leaves only, the Chinese teas being classified according to the position of the leaf on the young shoot. Thus the very highest quality of tea (not to be found in ordinary trade) is the *pekoe tip* or *flowery pekoe*, made of the leaf buds at the very end of the twig; the leaf next this bud, that is, the youngest leaf which has opened, makes the *orange pekoe*; the next older leaf, the *pekoe*; the third leaf the *souchong first*, and so on through several grades. The difference between green and black teas is due to the mode of preparation. Green tea is made by steaming and drying the leaves while fresh, while black tea is prepared by allowing the leaves to undergo an oxidative fermentation which darkens their color.

More than half the tea consumed in the United States comes from China, most of the remainder from Japan, smaller quantities from India, Ceylon, and the East Indies, and about one part in ten thousand of what we use is grown in South Carolina.

A special law governs the importation of tea into the United States, and each shipment must be tested and found to comply with the standard of the grade claimed for it before it is allowed to pass through the custom house.

So little of the tea enters the infusion which is consumed that it seems unnecessary for the purposes of this book to quote analyses of the tea leaf.

The stimulating property of the infusion is attributed to the alkaloid first called *theine* and later found to be identical with *caffeine*, the characteristic alkaloid of coffee. This alkaloid is chemically a tri-methyl-xanthine, $C_8H_{10}N_4O_2$, belonging to

the same group of substances with xanthine and hypoxanthine of meat extract.

The flavor of tea is also influenced by the tannin, and probably by the small amount of volatile oil which it contains.

Coffee is the seed of *Coffea arabica* or *Coffea liberica*. It was originally grown in Africa and Arabia, and afterward introduced into the East and West Indies and tropical America. It is estimated that at present Brazil furnishes over half the world's supply of coffee and nearly three fourths of that consumed in the United States.

The constituents of chief importance in coffee are the alkaloid caffeine which has just been described as occurring in tea, the caffetannic acid ($C_{15}H_{18}O_8$), and the volatile oil known as caffeoil ($C_8H_{10}O_2$) to which the characteristic flavor and aroma of coffee are chiefly attributed.

Cocoa in addition to the stimulating property due to the alkaloid *theobromine* ($C_7H_8N_4O_2$), and the flavor which makes it popular both as a beverage and in confectionery, has a considerable food value. A brief description of the chief cocoa products was given in the last chapter (page 436).

Other Beverages

Fruit juices, sometimes classed as beverages, are about equally entitled to recognition as foods with the fruits from which they are obtained. The fruits used commercially for this purpose are in most cases so juicy that what has been said of fruits as food in Chapter IX applies almost equally to the fresh fruit or its unfermented juice. Several analyses of fruit juices and references to the literature regarding them will be found in pages 335-365. It seems therefore unnecessary to discuss them separately here.

Wines have received much attention both from the standpoint of their place in the diet and in connection with pure food legislation. A discussion of the former topic would lead much

beyond the scope of this work; regarding the latter it will be sufficient to give the definitions and standards of the Association of Official Agricultural Chemists, which are as follows:

1. *Wine* is the product made by the normal alcoholic fermentation of the juice of sound, ripe grapes, and the usual cellar treatment,¹ and contains not less than seven (7) nor more than sixteen (16) per cent of alcohol, by volume, and, in one hundred (100) cubic centimeters (20° C.), not more than one tenth (0.1) gram of sodium chlorid nor more than two tenths (0.2) gram of potassium sulphate; and for red wine not more than fourteen hundredths (0.14) gram, and for white wine not more than twelve hundredths (0.12) gram of volatile acids produced by fermentation and calculated as acetic acid. *Red wine* is wine containing the red coloring matter of the skins of grapes. *White wine* is wine made from white grapes or the expressed fresh juice of other grapes.

2. *Dry wine* is wine in which the fermentation of the sugars is practically complete and which contains, in one hundred (100) cubic centimeters (20° C.) less than one (1) gram of sugars and for dry red wine not less than sixteen hundredths (0.16) gram of grape ash and not less than one and six tenths (1.6) grams of sugar-free grape solids, and for dry white wine not less than thirteen hundredths (0.13) gram of grape ash and not less than one and four tenths (1.4) grams of sugar-free grape solids.

3. *Fortified dry wine* is dry wine to which brandy has been added but which conforms in all other particulars to the standard of dry wine.

4. *Sweet wine* is wine in which the alcoholic fermentation has been arrested, and which contains, in one hundred (100) cubic centimeters (20° C.) not less than one (1) gram of sugars, and for sweet red wine not less than sixteen hundredths (0.16) gram of grape ash, and for sweet white wine not less than thirteen hundredths (0.13) gram of grape ash.

5. *Fortified sweet wine* is sweet wine to which wine spirits have been added. By act of Congress, "sweet wine" used for making fortified sweet wine and "wine spirits" used for such fortification are defined as follows (sec. 43, Act of October 1, 1890, 26 Stat., 567, as amended by section 68, Act of August 27, 1894, 28 Stat., 509, and further amended by Act of Congress approved June 7, 1906): "That the wine spirits mentioned in section 42 of this act is the product resulting from the distillation of fermented grape juice to which water may have been added prior to, during, or after fermentation, for the sole purpose of facilitating the fermentation and economical distillation thereof, and shall be held to include the products from grapes or

¹ The subject of sulphurous acid in wine was reserved for future consideration.

their residues, commonly known as grape brandy; and the pure sweet wine, which may be fortified free of tax, as provided in said section, is fermented grape juice only, and shall contain no other substance whatever introduced before, at the time of, or after fermentation, except as herein expressly provided; and such sweet wine shall contain not less than four per centum of saccharine matter, which saccharine strength may be determined by testing with Balling's saccharometer or must scale, such sweet wine, after the evaporation of the spirits contained therein, and restoring the sample tested to original volume by addition of water: *Provided*, That the addition of pure boiled or condensed grape must or pure crystallized cane or beet sugar or pure anhydrous sugar to the pure grape juice aforesaid, or the fermented product of such grape juice prior to the fortification provided by this Act for the sole purpose of perfecting sweet wine according to commercial standard, or the addition of water in such quantities only as may be necessary in the mechanical operation of grape conveyers, crushers, and pipes leading to fermenting tanks, shall not be excluded by the definition of pure sweet wine aforesaid: *Provided, however*, That the cane or beet sugar, or pure anhydrous sugar, or water, so used shall not in either case be in excess of ten (10) per centum of the weight of the wine to be fortified under this Act: *And provided further*, That the addition of water herein authorized shall be under such regulations and limitations as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may from time to time prescribe; but in no case shall such wines to which water has been added be eligible for fortification under the provisions of this Act where the same, after fermentation and before fortification, have an alcoholic strength of less than five per centum of their volume."

6. *Sparkling wine* is wine in which the after part of the fermentation is completed in the bottle, the sediment being disgorged and its place supplied by wine or sugar liquor, and which contains, in one hundred (100) cubic centimeters (20° C.), not less than twelve hundredths (0.12) gram of grape ash.

7. *Modified wine, ameliorated wine, corrected wine*, is the product made by the alcoholic fermentation, with the usual cellar treatment, of a mixture of the juice of sound, ripe grapes with sugar (sucrose), or a sirup containing not less than sixty-five (65) per cent of sugar (sucrose), and in quantity not more than enough to raise the alcoholic strength after fermentation, to eleven (11) per cent by volume.

8. *Raisin wine* is the product made by the alcoholic fermentation of an infusion of dried or evaporated grapes, or of a mixture of such infusion or of raisins with grape juice.

Brandy is spirit obtained by the distillation of wine. It usually contains from 40 to 50 per cent of alcohol.

Gin is a distilled spirit flavored with volatile oil of juniper and sometimes other aromatic substances. It usually contains 30 to 45 per cent of alcohol.

Rum is made by distillation of the product obtained by fermentation of cane sugar molasses as described in connection with the sugar industry (page 428). It contains about 50 per cent of alcohol.

Cordials are made by steeping fruits or aromatic herbs in brandy or neutral spirit and distilling the product. *Absinthe* is a cordial made by distilling an infusion of wormwood and therefore contains oil of wormwood on account of which it has been forbidden importation into the United States as adulterated under the Food and Drugs Act inasmuch as it contains an "added poisonous or deleterious substance."

Malt liquor has been defined as a beverage made by the alcoholic fermentation of an infusion of barley malt and hops, with or without unmalted grains. Whether the term *beer* should be used in a similar broad sense or be more closely defined has been much discussed but not officially determined. Beer ordinarily contains 3.5 to 4 per cent of alcohol.

Low alcohol beers are being manufactured to an increasing extent to meet the demand for a temperance drink having a beer flavor. In some parts of the United States the sale of ordinary alcoholic beverages is prohibited or severely restricted while those of alcohol content below a specified limit (often 2 per cent) are not subject to the prohibition or restriction. In some countries of Europe ordinary beer is taxed while beer of alcohol content less than 2.25 per cent is tax-free.

Whisky is distilled spirit made from grain, colored and flavored by storage in charred barrels or by addition of caramel and suitable flavor. It usually contains from 40 to 50 per cent of alcohol.

Vinegar

The term *vinegar*, originally implying a product made from wine, has now come to be used much more broadly. The kinds of vinegar recognized officially in the United States are shown by the following definitions and explanation taken from Food Inspection Decision 140 issued February 27, 1912:

Vinegar, cider vinegar, apple vinegar, is the product made from the alcoholic and subsequent acetous fermentations of the expressed juice of apples.

Wine vinegar, grape vinegar, is the product made by the alcoholic and subsequent acetous fermentations of the juice of grapes.

Malt vinegar is the product made by the alcoholic and subsequent acetous fermentations, without distillation, of an infusion of barley malt or cereals whose starch has been converted by malt.

Sugar vinegar is the product made by the alcoholic and subsequent acetous fermentations of solutions of sugar, sirup, molasses, or refiner's sirup.

Glucose vinegar is the product made by the alcoholic and subsequent acetous fermentations of solutions of starch sugar or glucose.

Spirit vinegar, distilled vinegar, grain vinegar, is the product made by the acetous fermentation of dilute distilled alcohol.

Several questions regarding these definitions have been raised and after investigation the board has reached the following conclusions:

Meaning of the term "vinegar." While the term "vinegar" in its etymological significance suggests only sour wine, it has come to have a broader significance in English-speaking countries. In the United States it has lost entirely its original meaning and when used without a qualifying word designates only the product secured by the alcoholic and subsequent acetous fermentation of apple juice.

"Second pressings." It is held that the number of pressings used in preparing the juice is immaterial so long as the pomace is fresh and not decomposed. The practice of allowing the pomace from the presses to stand in piles or in vats for a number of days, during which time it becomes heated and decomposed, and then pressing, securing what is ordinarily called "second pressing," in the opinion of the board produces a product which consists in whole or in part of a filthy and decomposed material and is therefore adulterated.

Vinegar from dried-apple products. The product made from dried-apple skins, cores, and chops, by the process of soaking, with subsequent alcoholic and acetous fermentations of the solution thus obtained, is not entitled to be called vinegar without further designation, but must be plainly marked to show the material from which it is produced. The dried stock from which this product is prepared must be clean and made from sound material.

Addition of water. When natural vinegars made from cider, wine, or the juice of other fruits are diluted with water, the label must plainly indicate this fact; as, for example, "diluted to — per cent acid strength." When water is added to pomace in the process of manufacture, the fact that the product is diluted must be plainly shown on the label in a similar manner. Dilution of vinegar naturally reduces, not only the acid strength, but the amount of other ingredients in proportion to the dilution, so that reduced vinegars will not comply with the analytical constants for undiluted products; but the relations existing between these various ingredients will remain the same. Diluted vinegars must have an acid strength of at least 4 grams acetic acid per 100 cubic centimeters.

Mixtures of vinegars. As different kinds of vinegar differ in source, flavor, and chemical composition, mixtures thereof are compounds within the meaning of the Food and Drugs Act, and if they contain no added poisonous or other added deleterious

ingredients, will not be held to be misbranded if plainly labeled with the word "compound," together with the names and proportions of the various ingredients.

Addition of boiled cider and coloring matter. The Food and Drugs Act provides that a product shall be deemed to be adulterated if it be mixed, colored, powdered, coated, or stained in a manner whereby damage or inferiority is concealed; and, in the opinion of the board, the addition of coloring matters, boiled cider, etc., to vinegar, wine vinegar, and the other types of vinegar, or mixtures thereof, is for the purpose of concealing damage or inferiority or producing an imitation product. In the first instance, the use of such products is an adulteration and therefore prohibited. Products artificially colored or flavored with harmless ingredients in imitation of some particular kind of vinegar will not be held to be misbranded if plainly labeled "Imitation vinegar" in accordance with the provisions of the law.

Mixture of distilled and sugar vinegars. The product prepared by submitting to acetous fermentation a mixture of dilute alcohol (obtained, for example, from molasses by alcoholic fermentation and subsequent distillation) and dilute molasses, which has undergone alcoholic fermentation, is not "molasses vinegar" but a compound of distilled vinegar and molasses vinegar; such mixtures, however, must contain a substantial amount of molasses vinegar and not a small amount for the purpose of coloring the distilled vinegar. The molasses used must be fit for food purposes and free from any added deleterious substances.

Acetic acid diluted. The product made by diluting acetic acid is not vinegar and when intended for food purposes must be free from harmful impurities and sold under its own name.

Product obtained by distilling wood. The impure product made by the destructive distillation of wood, known as "pyroligneous acid," is not vinegar nor suitable for food purposes.

Acid strength. All of the products described above should contain not less than four (4) grams of acetic acid per one hundred (100) cubic centimeters.

In addition to the requirement of 4 grams of acetic acid to 100 cc. in each case the full standards prescribe in the cases of several vinegars certain limits of solids, ash, alkalinity of ash, etc., designed to facilitate the identification of the vinegar as to its source and the judgment as to whether it is wholly genuine and true to name.

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APPENDIX A

RULES AND REGULATIONS FOR THE ENFORCEMENT OF THE FOOD AND DRUGS ACT

INTRODUCTION

UNDER date of October 17, 1906, forty rules and regulations for the enforcement of the food and drugs act, June 30, 1906, were adopted by the three Secretaries. Since that date eight regulations, Nos. 3, 5, 9, 15, 17, 19, 28, and 34, have been amended, the first named by F. I. D. 79, "Collection of Samples," approved by Secretary Wilson of the Department of Agriculture, Secretary Cortelyou of the Treasury Department, and Secretary Straus of the Department of Commerce and Labor, No. 5 by F. I. D. 130, "Amendment to Regulation 5, Hearings," No. 9 by F. I. D. 90, "Change in Form of Guaranty Legend," No. 15 to accord with F. I. D. 104 on Benzoate of Soda and Nos. 135, 138, and 142 on Saccharin, Nos. 17 and 19 by F. I. D. 84, "Label" and "Character of Name," No. 28 by F. I. D. 112, on "Labeling of Derivatives," and No. 34 by F. I. D. 93, "Denaturing," all over the signatures of the Secretaries of Agriculture, the Treasury, and Commerce and Labor, with the exception of F. I. D. 142, from which the Secretary of the Treasury dissented.

Regulation 2, Original Unbroken Package, has been interpreted by F. I. D. 86, and Regulation 9, Form of Guaranty, by F. I. D. 83, the latter an opinion rendered by the Attorney General on the issue of a guaranty based upon a guaranty.

In accordance with Regulation 15, Wholesomeness of Colors and Preservatives, F. I. D. 76, on Dyes, Chemicals, and Preservatives in Foods, F. I. D. 89, Relating to the Use in Foods of Benzoate of Soda and Sulphur Dioxid. F. I. D. 92, on the Use of Copper Salts, and F. I. D. 102, amending F. I. D. 92, have been issued over the signatures of the three Secretaries, constituting decisions on these points pending the completion of investigations and the issuance of final regulations governing the use of such substances. F. I. D. 104 constitutes the final decision on the use of benzoate of soda in foods, and allows such use; F. I. D. 135, 138, and 142, constitute the final decision on the use of saccharin in food and prohibit such use after April 1, 1912.

With the exception of these amendments and amplifications the regulations as originally issued remain unchanged, and no additional rules have been adopted, the revision issued under this date incorporating the changes enumerated, together with the amendments to section 8 of the food and drugs act.

D. F. HOUSTON, *Secretary of Agriculture*.

WASHINGTON, D. C., *March 21, 1913.*

RULES AND REGULATIONS AS AMENDED

GENERAL

Regulation 1. Short Title of the Act

The act, "For preventing the manufacture, sale, or transportation of adulterated or misbranded or poisonous or deleterious foods, drugs, medicines, and liquors, and for regulating traffic therein, and for other purposes," approved June 30, 1906, shall be known and referred to as "The Food and Drugs Act, June 30, 1906."

Regulation 2. Original Unbroken Package

[See also F. I. D. 86 for interpretation of this regulation.]

(Section 2.)

The term "original unbroken package" as used in this act is the original package, carton, case, can, box, barrel, bottle, phial, or other receptacle put up by the manufacturer, to which the label is attached, or which may be suitable for the attachment of a label, making one complete package of the food or drug article. The original package contemplated includes both the wholesale and the retail package.

Regulation 3. Collection of Samples

[As amended by F. I. D. 79, October 8, 1907, to take effect November 1, 1907.]

(Section 4.)

Samples of unbroken packages shall be collected only by authorized agents of the Department of Agriculture, or by the health, food, or drug officer of any State, Territory, or the District of Columbia, when commissioned by the Secretary of Agriculture for this purpose.

Samples may be purchased in the open market, and, if in bulk, the marks, brands, or tags upon the package, carton, container, wrapper, or accompanying printed or written matter shall be noted. The collector shall also note the names of the vendor and agent through whom the sale was actually made, together with the date of the purchase. The collectors shall purchase representative samples.

A sample taken from bulk goods shall be divided into three parts, and each shall be labeled with the identifying marks.

If a package be less than 4 pounds, or in volume less than 2 quarts, three packages shall be purchased, when practicable, and the marks and tags upon each noted as above. When three samples are purchased, one sample shall be delivered to the Bureau of Chemistry or to such chemist or examiner as may be designated by the Secretary of Agriculture; the second and third samples shall be held under seal by the Secretary of Agriculture, who, upon request, shall deliver one of such samples to the party from whom purchased or to the party guaranteeing such merchandise.

When it is impracticable to collect three samples, or to divide the sample or samples, the order of delivery outlined above shall obtain, and in case there is a second sample the Secretary of Agriculture may, at his discretion, deliver such sample to parties interested.

All samples shall be sealed by the collector with a seal provided for the purpose.

Regulation 4. Methods of Analysis (Section 4.)

Unless otherwise directed by the Secretary of Agriculture, the methods of analysis employed shall be those prescribed by the Association of Official Agricultural Chemists and the United States Pharmacopœia.

Regulation 5. Hearings

[As amended by F. I. D. 130, January 18, 1911.]

(Section 4.)

(a) When the examination or analysis shows that samples are adulterated or misbranded within the meaning of this act notice of that fact shall be given in every case to the party or parties against whom prosecution lies under this act for the shipment or manufacture or sale of the particular product and such other interested parties as the Secretary of Agriculture may direct, and a date shall be fixed at which such party or parties may be heard before the Secretary of Agriculture or such other person as he may direct. The hearings shall be had at places designated by the Secretary of Agriculture most convenient for all parties concerned. These hearings shall be private and confined to questions of fact. The parties interested therein may appear in person or by attorney and may submit oral or written evidence to show any fault or error in the findings of the analyst or examiner. Interested parties may present proper interrogatories to analysts, to be submitted to and propounded by the Secretary of Agriculture or the officer conducting the hearing. Such privilege, however, shall not include the right of cross-examination. The Secretary of Agriculture may order a reëxamination of the sample or have new samples drawn for further examination.

(b) If, after hearings held, it appears that a violation of the act has been committed, the Secretary of Agriculture shall give notice to the proper United States attorney.

(c) Any health, food, or drug officer or agent of any State, Territory, or the District of Columbia who shall obtain satisfactory evidence of any violation of the Food and Drugs Act, June 30, 1906, as provided by section 5 thereof, shall first submit the same to the Secretary of Agriculture in order that he may give notice and fix dates for hearings to the proper parties.

Regulation 6. Publication

(Section 4.)

(a) When a judgment of the court shall have been rendered there may be a publication of the findings of the examiner or analyst, together with the findings of the court.

(b) This publication may be made in the form of circulars, notices, or bulletins, as the Secretary of Agriculture may direct, not less than thirty days after judgment.

(c) If an appeal be taken from the judgment of the court before such publication, notice of the appeal shall accompany the publication.

Regulation 7. Standards for Drugs

(Section 7.)

(a) A drug bearing a name recognized in the United States Pharmacopœia or National Formulary, without any further statement respecting its character, shall be required to conform in strength, quality, and purity to the standards prescribed or indicated for a drug of the same name recognized in the United States Pharmacopœia or National Formulary, official at the time.

(b) A drug bearing a name recognized in the United States Pharmacopœia or National Formulary, and branded to show a different standard of strength, quality, or purity, shall not be regarded as adulterated if it conforms to its declared standard.

Regulation 8. Formulas — Proprietary Foods

(Section 8, last paragraph.)

(a) Manufacturers of proprietary foods are only required to state upon the label the names and percentages of the materials used, in so far as the Secretary of Agriculture may find this to be necessary to secure freedom from adulteration and misbranding.

(b) The factories in which proprietary foods are made shall be open at all reasonable times to the inspection provided for in Regulation 16.

Regulation 9. Form of Guaranty

[As amended December 8, 1908, by F. I. D. 99, to take effect on January 1, 1909; see also F. I. D. 83 for opinion of the Attorney-General on the issue of a guaranty based upon a former guaranty.]

(Section 9.)

(a) No dealer in food or drug products will be liable to prosecution if he can establish that the goods were sold under a guaranty by the wholesaler, manufacturer, jobber, dealer, or other party residing in the United States from whom purchased.

(b) A general guaranty may be filed with the Secretary of Agriculture by the manufacturer or dealer and be given a serial number, which number shall appear on each and every package¹ of goods sold under such guaranty with the words "Guaranteed by [insert name of guarantor] under the food and drugs act, June 30, 1906."

(c) The following form of guaranty is suggested :

I (we) the undersigned do hereby guarantee that the articles of foods or drugs manufactured, packed, distributed, or sold by me (us) [specifying the same as fully as possible] are not adulterated or misbranded within the meaning of the food and drugs act, June 30, 1906.

(Signed in ink.)

[Name and place of business of wholesaler, dealer, manufacturer, jobber, or other party.]

(d) If the guaranty be not filed with the Secretary of Agriculture as above, it should identify and be attached to the bill of sale, invoice, bill of lading, or other schedule giving the names and quantities of the articles sold.

ADULTERATION**Regulation 10. Confectionery**

(Section 7.)

(a) Mineral substances of all kinds (except as provided in Regulation 15) are specifically forbidden in confectionery whether they be poisonous or not.

¹ This provision has been revoked by Food Inspection, Decision 153.

(b) Only harmless colors or flavors shall be added to confectionery.

(c) The term "narcotic drugs" includes all the drugs mentioned in section 8, food and drugs act, June 30, 1906, relating to foods, their derivatives and preparations, and all other drugs of a narcotic nature.

Regulation 11. Substances Mixed and Packed with Foods

(Section 7, under "Foods.")

No substance may be mixed or packed with a food product which will reduce or lower its quality or strength. Not excluded under this provision are substances properly used in the preparation of food products for clarification or refining, and eliminated in the further process of manufacture.

Regulation 12. Coloring, Powdering, Coating and Staining

(Section 7, under "Foods.")

(a) Only harmless colors may be used in food products.

(b) The reduction of a substance to a powder to conceal inferiority in character is prohibited.

(c) The term "powdered" means the application of any powdered substance to the exterior portion of articles of food, or the reduction of a substance to a powder.

(d) The term "coated" means the application of any substance to the exterior portion of a food product.

(e) The term "stain" includes any change produced by the addition of any substance to the exterior portion of foods which in any way alters their natural tint.

Regulation 13. Natural Poisonous or Deleterious Ingredients

(Section 7, paragraph 5, under "Foods.")

Any food product which contains naturally a poisonous or deleterious ingredient does not come within the provisions of

the food and drugs act, June 30, 1906, except when the presence of such ingredient is due to filth, putrescence, or decomposition.

Regulation 14. External Application of Preservatives

(Section 7, paragraph 5, under "Foods," proviso.)

(a) Poisonous or deleterious preservatives shall only be applied externally, and they and the food products shall be of a character which shall not permit the permeation of any of the preservative to the interior, or any portion of the interior, of the product.

(b) When these products are ready for consumption, if any portion of the added preservative shall have penetrated the food product, then the proviso of section 7, paragraph 5, under "Foods" shall not obtain, and such food products shall then be subject to the regulations for food products in general.

(c) The preservative applied must be of such a character that, until removed, the food products are inedible.

Regulation 15. Wholesomeness of Colors and Preservatives

[As amended to accord with F. I. D. 104. See also F. I. D. 76, 86, 92, 101, 102, 135, and 138 for rulings under this head.]

(Section 7, paragraph 5, under "Foods.")

(a) Respecting the wholesomeness of colors, preservatives, and other substances which are added to foods, the Secretary of Agriculture shall determine from chemical or other examination, under the authority of the agricultural appropriation act, Public 382, approved June 30, 1906, the names of those substances which are permitted or inhibited in food products; and such findings, when approved by the Secretary of the Treasury and the Secretary of Commerce and Labor, shall become a part of these regulations.

(b) The Secretary of Agriculture shall determine from time to time, in accordance with the authority conferred by the

agricultural appropriation act, Public 382, approved June 30, 1906, the principles which shall guide the use of colors, preservatives, and other substances added to foods; and when concurred in by the Secretary of the Treasury and the Secretary of Commerce and Labor, the principles so established shall become a part of these regulations.

(c) It having been determined that benzoate of soda mixed with food is not deleterious or poisonous and is not injurious to health, no objection will be raised under the food and drugs act to the use in food of benzoate of soda, provided that each container or package of such food is plainly labeled to show the presence and amount of benzoate of soda. Food Inspection Decisions 76 and 89 are amended accordingly.

(d) It having been determined that saccharin mixed with food is an added poisonous and deleterious ingredient such as is contemplated by the act, and also that the substitution of saccharin for sugar in foods reduces and lowers their quality, the Secretary of Agriculture will regard as adulterated under the food and drugs act foods containing saccharin which, on or after April 1, 1912, are manufactured or offered for sale in the District of Columbia or Territories or shipped in interstate or foreign commerce, or offered for importation into the United States. (F. I. D. 135, 138, and 142, dated April 26 and June 20, 1911, and March 1, 1912, respectively.)

Regulation 16. Character of the Raw Materials

(Section 7. paragraph 1, under "Drugs;" paragraph 6, under "Foods.")

(a) The Secretary of Agriculture, when he deems it necessary, shall examine the raw materials used in the manufacture of food and drug products, and determine whether any filthy, decomposed, or putrid substance is used in their preparation.

(b) The Secretary of Agriculture shall make such inspections as often as he may deem necessary.

MISBRANDING

Regulation 17. Label

[As amended by F. I. D. 84, January 31, 1908, taking effect February 10, 1908.]

(Section 8.)

(a) The term "label" applies to any printed, pictorial or other matter upon or attached to any package of a food or drug product, or any container thereof subject to the provisions of this act.

(b) The principal label shall consist, first, of all information which the food and drugs act, June 30, 1906, specifically requires, to wit, the name of the place of manufacture in the case of food compounds or mixtures sold under a distinctive name; statements which show that the articles are compounds, mixtures, or blends; the words "compound," "mixture," or "blend," and words designating substances or their derivatives and proportions required to be named in the case of foods and drugs. All this information shall appear upon the principal label, and should have no intervening descriptive or explanatory reading matter. Second, if the name of the manufacturer and place of manufacture are given, they should also appear upon the principal label. Third, preferably upon the principal label, in conjunction with the name of the substance, such phrases as "artificially colored," "colored with sulphate of copper," or any other such descriptive phrases necessary to be announced should be conspicuously displayed. Fourth, elsewhere upon the principal label other matter may appear in the discretion of the manufacturer. If the contents are stated in terms of weight or measure, such statement should appear upon the principal label and must be couched in plain terms, as required by Regulation 29.

(c) If the principal label is in a foreign language, all information required by law and such other information as indicated above in (b) shall appear upon it in English. Besides the prin-

principal label in the language of the country of production, there may be also one or more other labels, if desired, in other languages, but none of them more prominent than the principal label, and these other labels must bear the information required by law, but not necessarily in English. The size of the type used to declare the information required by the act shall not be smaller than 8-point (brevier) capitals: *Provided*, That in case the size of the package will not permit the use of 8-point type, the size of the type may be reduced proportionately.

(d) Descriptive matter upon the label shall be free from any statement, design, or device regarding the article or the ingredients or substances contained therein, or quality thereof, or place of origin, which is false or misleading in any particular. The term " design " or " device " applies to pictorial matter of every description, and to abbreviations, characters, or signs for weights, measures, or names of substances.

(e) An article containing more than one food product or active medicinal agent is misbranded if named after a single constituent.

In the case of drugs the nomenclature employed by the United States Pharmacopœia and the National Formulary shall obtain.

(f) The use of any false or misleading statement, design, or device appearing on any part of the label shall not be justified by any statement given as the opinion of an expert or other person, nor by any descriptive matter explaining the use of the false or misleading statement given as the opinion of an expert or other person, nor by any descriptive matter explaining the use of the false or misleading statement, design, or device.

Regulation 18. Name and Address of Manufacturer

(Section 8.)

(a) The name of the manufacturer or producer, or the place where manufactured, except in case of mixtures and compounds having a distinctive name, need not be given upon the label,

but if given, must be the true name and the true place. The words "packed for —," "distributed by —," or some equivalent phrase, shall be added to the label in case the name which appears upon the label is not that of the actual manufacturer or producer, or the name of the place not the actual place of manufacture or production.

(b) When a person, firm, or corporation actually manufactures or produces an article of food or drug in two or more places, the actual place of manufacture or production of each particular package need not be stated on the label except when in the opinion of the Secretary of Agriculture the mention of any such place, to the exclusion of the others, misleads the public.

Regulation 19. Character of Name

[As amended by F. I. D. 84, January 31, 1908, taking effect February 10, 1908.]

(Section 8.)

(a) A simple or unmixed food or drug product not bearing a distinctive name should be designated by its common name in the English language; or if a drug, by any name recognized in the United States Pharmacopœia or National Formulary. No further description of the components or qualities is required, except as to content of alcohol, morphine, etc.

(b) The use of a geographical name shall not be permitted in connection with a food or drug product not manufactured or produced in that place, when such name indicates that the article was manufactured or produced in that place.

(c) The use of a geographical name in connection with a food or drug product will not be deemed a misbranding when by reason of long usage it has come to represent a generic term and is used to indicate a style, type, or brand; but in all such cases the State or Territory where any such article is manufactured or produced shall be stated upon the principal label.

(d) A foreign name which is recognized as distinctive of a product of a foreign country shall not be used upon an article

of domestic origin except as an indication of the type or style of quality or manufacture, and then only when so qualified that it cannot be offered for sale under the name of a foreign article.

Regulation 20. Distinctive Name

(Section 8.)

(a) A "distinctive name" is a trade, arbitrary, or fancy name which clearly distinguishes a food product, mixture, or compound from any other food product, mixture, or compound.

(b) A distinctive name shall not be one representing any single constituent of a mixture or compound.

(c) A distinctive name shall not misrepresent any property or quality of a mixture or compound.

(d) A distinctive name shall give no false indication of origin, character, or place of manufacture, nor lead the purchaser to suppose that it is any other food or drug product.

Regulation 21. Compounds, Imitations, or Blends Without Distinctive Name

(Section 8.)

(a) The term "blend" applies to a mixture of like substances, not excluding harmless coloring or flavoring ingredients used for the purpose of coloring and flavoring only.

(b) If any age is stated, it shall not be that of a single one of its constituents, but shall be the average of all constituents in their respective proportions.

(c) Coloring and flavoring cannot be used for increasing the weight or bulk of a blend.

(d) In order that colors or flavors may not increase the volume or weight of a blend, they are not to be used in quantities exceeding 1 pound to 800 pounds of the blend.

(e) A color or flavor cannot be employed to imitate any natural product or any other product of recognized name and quality.

(f) The term "imitation" applies to any mixture or compound

which is a counterfeit or fraudulent simulation of any article of food or drug.

Regulation 22. Articles without a Label

(Section 8, paragraph 1, under "Drugs;" paragraph 1, under "Foods.")

It is prohibited to sell or offer for sale a food or drug product bearing no label upon the package or no descriptive matter whatever connected with it, either by design, device, or otherwise, if said product be an imitation of or offered for sale under the name of another article.

Regulation 23. Proper Branding not a Complete Guaranty

Packages which are correctly branded as to character of contents, place of manufacture, name of manufacturer, or otherwise, may be adulterated and hence not entitled to enter into interstate commerce.

Regulation 24. Incompleteness of Branding

A compound shall be deemed misbranded if the label be incomplete as to the names of the required ingredients. A simple product does not require any further statement than the name or distinctive name thereof, except as provided in Regulations 19 (a) and 28.

Regulation 25. Substitution

(Sections 7 and 8.)

(a) When a substance of a recognized quality commonly used in the preparation of a food or drug product is replaced by another substance not injurious or deleterious to health, the name of the substituted substance shall appear upon the label.

(b) When any substance which does not reduce, lower, or injuriously affect its quality or strength, is added to a food or drug product, other than that necessary to its manufacture or refining, the label shall bear a statement to that effect.

Regulation 26. Waste Materials

(Section 8.)

When an article is made up of refuse materials, fragments, or trimmings, the use of the name of the substance from which they are derived, unless accompanied by a statement to that effect, shall be deemed a misbranding. Packages of such materials may be labeled "pieces," "stems," "trimmings," or with some similar appellation.

Regulation 27. Mixtures or Compounds with Distinctive Names

(Section 8. First proviso under "Foods," paragraph 1.)

(a) The terms "mixtures" and "compounds" are interchangeable and indicate the results of putting together two or more food products.

(b) These mixtures or compounds shall not be imitations of other articles, whether simple, mixt, or compound, or offered for sale under the name of other articles. They shall bear a distinctive name and the name of the place where the mixture or compound has been manufactured or produced.

(c) If the name of the place be one which is found in different States, Territories, or countries, the name of the State, Territory, or country, as well as the name of the place, must be stated.

Regulation 28. Substances named in Drugs or Foods

(As amended by F. I. D. 112, January 6, 1910, taking effect April 1, 1910.)

(Section 8. Second under "Drugs;" second under "Foods.")

(a) The term "alcohol" is defined to mean common or ethyl alcohol. No other kind of alcohol is permissible in the manufacture of drugs except as specified in the United States Pharmacopœia or National Formulary.

(b) The words alcohol, morphine, opium, etc., and the quantities and proportions thereof, shall be printed in letters corresponding in size with those prescribed in Regulation 17, paragraph (c).

(c) A drug, or food product except in respect of alcohol, is

misbranded in case it fails to bear a statement on the label of the quantity or proportion of any alcohol, morphine, opium, heroin, cocaine, alpha or beta eucaine, chloroform, cannabis indica, chloral hydrate, or acetanilide, or any derivative or preparation of any such substances contained therein.

(d) A statement of the maximum quantity or proportion of any such substances present will meet the requirements, provided the maximum stated does not vary materially from the average quantity of proportion.

(e) In case the actual quantity or proportion is stated it shall be the average quantity or proportion with the variations noted in Regulation 29.

(f) The following are the principal derivatives and preparations made from the articles which are required to be named upon the label:

ALCOHOL, ETHYL: (*Cologne spirits, Grain alcohol, Rectified spirits, Spirits, and Spirits of wine.*)

Derivatives —

Aldehyde, Ether, Ethyl acetate, Ethyl nitrite, and Paraldehyde.

Preparations containing alcohol —

Bitters, Brandies, Cordials, Elixirs, Essences, Fluid extracts, Spirits, Sirups, Tinctures, Tonics, Whiskies, and Wines.

MORPHINE, ALKALOID:

Derivatives —

Apomorphine, Dionine, Peronine, Morphine acetate, Hydrochloride, Sulphate, and other salts of morphine.

Preparations containing morphine or derivatives of morphine —

Bougies, Catarrh Snuff, Chlorodyne, Compound powder of morphine, Crayons, Elixirs, Granules, Pills, Solutions, Sirups, Suppositories, Tablets, Triturates, and Troches.

OPIUM, GUM:

Preparations of opium —

Extracts, Denarcotized opium, Granulated opium, and Powdered opium, Bougies, Brown mixture, Carminative mixtures, Crayons, Dover's powder, Elixirs, Liniments, Ointments, Paregoric, Pills, Plasters, Sirups, Suppositories, Tablets, Tinctures, Troches, Vinegars, and Wines.

Derivatives —

Codeine, Alkaloid, Hydrochloride, Phosphate, Sulphate, and other salts of codeine.

Preparations containing codeine or its salts —

Elixirs, Pills, Sirups, and Tablets.

COCAINE, ALKALOID :

Derivatives —

Cocaine hydrochloride, Oleate, and other salts.

Preparations containing cocaine or salts of cocaine —

Coca leaves, Catarrh powders, Elixirs, Extracts, Infusion of coca, Ointments, Paste pencils, Pills, Solutions, Sirups, Tablets, Tinctures, Troches, and Wines.

HEROIN :

Preparations containing heroin —

Sirups, Elixirs, Pills, and Tablets.

ALPHA AND BETA EUCAINE :

Preparations —

Mixtures, Ointments, Powders, and Solutions.

CHLOROFORM :

Preparations containing chloroform —

Chloranodyne, Elixirs, Emulsions, Liniments, Mixtures, Spirits, and Sirups.

CANNABIS INDICA :

Preparations of cannabis indica —

Corn remedies, Extracts, Mixtures, Pills, Powders, Tablets, and Tinctures.

CHLORAL HYDRATE (*Chloral*, U. S. Pharmacopœia, 1890) :*Derivatives —*

Chloral acetophenonoxim, Chloral alcoholate, Chloralamide, Chloralimide, Chloral orthoform, Chloralose, Dormiol, Hypnal, and Uraline.

Preparations containing chloral hydrate or its derivatives —

Chloral camphorate, Elixirs, Liniments, Mixtures, Ointments, Suppositories, Sirups, and Tablets.

ACETANILIDE (*Antifebrine*, *Phenylacetamide*) :*Derivatives —*

Acetphenetidine, Citrophén, Diacetanilide, Lactophenin, Methoxyacetanilide, Methylacetanilide, Para-Iodoacetanilide, and Phenacetine.

Preparations containing acetanilide or derivatives —

Analgesics, Antineuralgics, Antirheumatics, Cachets, Capsules, Cold remedies, Elixirs, Granular effervescing salts, Headache powders, Mixtures, Pain remedies, Pills, and Tablets.

(g) In declaring the quantity or proportion of any of the specified substances the names by which they are designated in the act shall be used, and in declaring the quantity or proportion of derivatives of any of the specified substances, in addition to the trade name of the derivative, the name of the specified substance shall also be stated, so as to indicate clearly that the product is a derivative of the particular specified substance.

Regulation 29. Statement of Weight or Measure

(Section 8. Third under "Foods.")

[The section of the law under which this regulation was made has been amended by the act of March 3, 1913, Public No. 419, H. R. 22526. New regulations will be published as soon as they have been adopted.]

(a) A statement of the weight or measure of the food contained in a package is not required. If any such statement is printed, it shall be a plain and correct statement of the average net weight or volume, either on or immediately above or below the principal label, and of the size of letters specified in Regulation 17.

(b) A reasonable variation from the stated weight for individual packages is permissible, provided this variation is as often above as below the weight or volume stated. This variation shall be determined by the inspector from the changes in the humidity of the atmosphere, from the exposure of the package to evaporation or to absorption of water, and the reasonable variations which attend the filling and weighing or measuring of a package.

Regulation 30. Method of Stating Quantity or Proportion

(Section 8.)

In the case of alcohol the expression "quantity" or "proportion" shall mean the average percentage by volume in the finished product. In the case of the other ingredients required to be named upon the label, the expression "quantity" or "proportion" shall mean grains or minims per ounce or fluid

ounce, and also, if desired, the metric equivalents therefor, or milligrams per gram or per cubic centimeter, or grams or cubic centimeters per kilogram or per liter; provided that these articles shall not be deemed misbranded if the maximum of quantity or proportion be stated, as required in Regulation 28 (*d*).

EXPORTS AND IMPORTS OF FOODS AND DRUGS

Regulation 31. Preparation of Food Products for Export

(Section 2.)

(*a*) Food products intended for export may contain added substances not permitted in foods intended for interstate commerce, when the addition of such substances does not conflict with the laws of the countries to which the food products are to be exported and when such substances are added in accordance with the directions of the foreign purchaser or his agent.

(*b*) The exporter is not required to furnish evidence that goods have been prepared or packed in compliance with the laws of the foreign country to which said goods are intended to be shipped, but such shipment is made at his own risk.

(*c*) Food products for export under this regulation shall be kept separate and labeled to indicate that they are for export.

(*d*) If the products are not exported they shall not be allowed to enter interstate commerce.

Regulation 32. Imported Food and Drug Products

(Section 11.)

(*a*) Meat and meat food products imported into the United States shall be accompanied by a certificate of official inspection of a character to satisfy the Secretary of Agriculture that they are not dangerous to health, and each package of such articles shall bear a label which shall identify it as covered by the certificate, which certificate shall accompany or be attached to the invoice on which entry is made.

(b) The certificate shall set forth the official position of the inspector and the character of the inspection.

(c) Meat and meat food products as well as all other food and drug products of a kind forbidden entry into or forbidden to be sold or restricted in sale in the country in which made or from which exported, will be refused admission.

(d) Meat and meat food products which have been inspected and passed through the customs may, if identity is retained, be transported in interstate commerce.

Regulation 33. Declaration

(Section 11.)

(a) All invoices of food or drug products shipped to the United States shall have attached to them a declaration of the shipper, made before a United States consular officer, as follows :

I, the undersigned, do solemnly and truly declare that I am the ————
(Manufacturer, agent, or shipper.)
of the merchandise herein mentioned and described, and that it consists of food or drug products which contain no added substances injurious to health.

These products were grown in ———— and manufactured in ———— by ————
(Country.) (Country.) (Name
——— during the year ————, and are exported from ———— and consigned to
of manufacturer.) (City.)

———. The products bear no false labels or marks, contain no added
(City.) some
coloring matter or preservative ————, and are not of a character to cause
(Name of added color or preservative.)

prohibition or restriction in the country where made or from which exported.

Dated at ———— this ———— day of ————, 19——.

(Signed): ————.

(b) In the case of importations to be entered at New York, Boston, Philadelphia, Chicago, San Francisco, and New Orleans, and other ports where food and drug inspection laboratories shall be established, this declaration shall be attached to the invoice on which entry is made. In other cases the declaration shall be attached to the copy of the invoice sent to the Bureau of Chemistry.

Regulation 34. Denaturing

[As amended by F. I. D. 93, May 12, 1908.]

(Section 11.)

Unless otherwise declared on the invoice, all substances ordinarily used as food products will be treated as such. Shipments of substances ordinarily used as food products intended for technical purposes should be accompanied by a declaration stating that fact. Such products should be denatured before entry, but denaturing may be allowed under customs supervision with the consent of the Secretary of the Treasury, or the Secretary of the Treasury may release such products without denaturing, under such conditions as may preclude the possibility of their use as food products.

Regulation 35. Bond, Imported Foods, and Drugs

(Section 11.)

Unexamined packages of food and drug products may be delivered to the consignee prior to the completion of the examination to determine whether the same are adulterated or misbranded upon the execution of a penal bond by the consignee in the sum of the invoice value of such goods with the duty added, for the return of the goods to customs custody.

Regulation 36. Notification of Violation of the Law

(Section 11.)

If the sample on analysis or examination be found not to comply with the law, the importer shall be notified of the nature of the violation, the time and place at which final action will be taken upon the question of the exclusion of the shipment, and that he may be present, and submit evidence (Form No. 5), which evidence, with a sample of the article, shall be forwarded to the Bureau of Chemistry at Washington, accompanied by the appropriate report card.

Regulation 37. Appeal to the Secretary of Agriculture and Remuneration
(Section 11.)

All applications for relief from decisions arising under the execution of the law should be addressed to the Secretary of Agriculture, and all vouchers or accounts for remuneration for samples shall be filed with the chief of the inspection laboratory, who shall forward the same, with his recommendation, to the Department of Agriculture for action.

Regulation 38. Shipment beyond the jurisdiction of the United States
(Section 11.)

The time allowed the importer for representations regarding the shipment may be extended at his request to permit him to secure such evidence as he desires, provided that this extension of time does not entail any expense to the Department of Agriculture. If at the expiration of this time, in view of the data secured in inspecting the sample and such evidence as may have been submitted by the manufacturers or importers, it appears that the shipment cannot be legally imported into the United States, the Secretary of Agriculture shall request the Secretary of the Treasury to refuse to deliver the shipment in question to the consignee, and to require its reshipment beyond the jurisdiction of the United States.

Regulation 39. Application of Regulations

These regulations shall not apply to domestic meat and meat food products which are prepared, transported, or sold in interstate or foreign commerce under the meat-inspection law and the regulations of the Secretary of Agriculture made thereunder. (This regulation has since been revoked.)

Regulation 40. Alteration and Amendment of Regulations

These regulations may be altered or amended at any time, without previous notice, with the concurrence of the Secretary of the Treasury, the Secretary of Agriculture, and the Secretary of Commerce and Labor.

APPENDIX B

FOOD INSPECTION DECISIONS¹

FOOD INSPECTION DECISION 44

SCOPE AND PURPOSE OF FOOD INSPECTION DECISIONS

From the tenor of many inquiries received in this Department it appears that many persons suppose that the answers to inquiries addressed to this Department, either in letters or in published decisions, have the force and effect of the rules and regulations for the enforcement of the food and drugs act of June 30, 1906. The following are illustrations of the inquiries received by this Department:

Must we stamp all goods as conforming to the drug and food law, whether they have alcohol and narcotics therein, or not?

On a brand of salad oil, which is a winter-strain cotton-seed oil, can it be sold under the brand of salad oil, or must it state that it is cotton-seed oil?

It seems highly desirable that an erroneous opinion of this kind should be corrected. The opinions or decisions of this Department do not add anything to the rules and regulations nor take anything away from them. They therefore are not to be considered in the light of rules and regulations. On the other hand, the decisions and opinions referred to express the attitude of this Department in relation to the interpretation of the law and the rules and regulations, and they are published for the information of the officials of the Department who may be charged with the execution of the law and especially to acquaint manufacturers, jobbers, and dealers with the attitude of this Department in these matters. They are therefore issued more

¹ Since space does not permit the quoting of all food inspection decisions in full the attempt has been made to reproduce here such selections as will be most useful to readers of this book.

in an advisory than in a mandatory spirit. It is clear that if the manufacturers, jobbers, and dealers interpret the rules and regulations in the same manner as they are interpreted by this Department, and follow that interpretation in their business transactions, no prosecution will lie against them. It needs no argument to show that the Secretary of Agriculture must himself come to a decision in every case before a prosecution can be initiated, since it is on his report that the district attorney is to begin a prosecution for the enforcement of the provisions of the act.

In so far as possible it is advisable that the opinions of this Department respecting the questions which arise may be published. It may often occur that the opinion of this Department is not that of the manufacturer, jobber, or dealer. In this case there is no obligation resting upon the manufacturer, jobber, or dealer to follow the line of procedure marked out or indicated by the opinion of this Department. Each one is entitled to his own opinion and interpretation and to assume the responsibility of acting in harmony therewith.

It may be proper to add that in reaching opinions and decisions on these cases the Department keeps constantly in view the two great purposes of the food and drugs act, namely, to prevent misbranding and to prohibit adulteration. From the tenor of the correspondence received at this Department and from the oral hearings which have been held, it is evident that an overwhelming majority of the manufacturers, jobbers, and dealers of this country are determined to do their utmost to conform to the provisions of the act, to support it in every particular, and to accede to the opinions of this Department respecting its construction. It is hoped, therefore, that the publication of the opinions and decisions of the Department will lead to the avoidance of litigation which might arise due to decisions which may be reached by this Department indicating violations of the act, violations which would not have occurred had the

opinions and decisions of the Department been brought to the attention of the offender.

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *December 1, 1906.*

FOOD INSPECTION DECISION 52

FORM OF LABEL

The following is an extract from a letter recently received :

We do not understand the requirements of the regulations respecting the arrangement of labels ; that is, the order in which the various features of the label should be arranged.

To meet the requests for the opinion of the Department regarding the proper arrangement of a label, the following order is suggested :

1. Name of substance or product.
2. In case of foods, words which indicate that the articles are compounds, mixtures, or blends, and the word "Imitation," "Compound," or "Blend," as the case may be.
3. Statements designating the quantity or proportions of the ingredients enumerated in the law, or derivatives and preparations of same,¹ as mentioned under Regulation 28; also statements of other extraneous substances whose presence should be declared, such as harmless coloring matter, or any necessary statement regarding grade or quality.

(The statements specified in paragraphs 1, 2, and 3, should appear together without any intervening descriptive or explanatory matter.)

4. Name of manufacturer (if given).
5. Place of manufacture (if given, or when required in case of food mixtures or compounds bearing a distinctive name).

It is stated in Regulation 17 that if the name of the manufacturer and place of manufacture be given they should appear

¹ Attention is called to the fact that the declaration of alcohol and its derivatives is not required in foods.

upon the principal label. Although the law does not require that the name of the manufacturer be given, or the place of manufacture, except in case of food mixtures and compounds having a distinctive name, it is held that if they are given they must be true, and should be placed with the required information on the principal label. The arrangement of the label is the same for both food and drug products and an example of each is given.

SAMPLE LABEL FOR FOOD PRODUCT

[Name of product.]
[Declaration required by
paragraphs 2 and 3.]

[Name of manufacturer,
if given.]
[Place of manufacture, if
given.]

KETCHUP. ARTIFICIALLY COLORED. [Descriptive matter, if desired, but preferably at bottom of label.] BLANK & CO., PORTLAND, ME. [Descriptive matter, if desired.]
--

SAMPLE LABEL FOR DRUG PRODUCT

[Name of product.]
[Declarations required
by paragraphs 2 and 3.]

[Name of manufacturer,
if given.]
[Place of manufacture, if
given.]

COUGH SYRUP. ALCOHOL, 10 PER CENT. MORPHINE, $\frac{1}{2}$ GRAIN PER OUNCE. CHLOROFORM, 40 MINIMS PER OUNCE. [Descriptive matter, if desired, but preferably at bottom of label.] JOHN JONES & CO., WASHINGTON, D.C. [Descriptive matter, if desired.]

Any descriptive or explanatory matter that may appear on the principal label, therefore, should be placed at the bottom of the label, or between No. 3 and No. 4, and should be clearly separated from other features of the label by means of a suitable line or space. Statements regarding the reason for using alcohol, artificial coloring matter, and other extraneous substances, come under the head of descriptive or explanatory matter, and should not be interspersed with the declarations required under Nos. 2 and 3.

The information called for under No. 3 should be so worded as to give only the required information, as, for example, "alcohol 17 per cent" or "artificially colored." All numbers used in expressing quantity or proportion of substances required to be stated (see Regulation 28) should be expressed in the Arabic notation.

Each substance required to be declared under No. 3 should be printed on a separate line and in type specified in Regulation 17 (c).

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *January 18, 1907.*

FOOD INSPECTION DECISION 58

THE LABELING OF PRODUCTS USED AS FOODS AND DRUGS AS WELL AS FOR TECHNICAL AND OTHER PURPOSES

Frequent requests for information relative to the proper labeling of products bearing the names of foods and drugs, but used also for technical and other purposes, are received. The following are typical:

We will kindly ask you to advise us in regard to the new law that governs the line of oils. We manufacture a compound product, so-called "turpentine," which contains pure turpentine and a very fine petroleum product. It

is used in most branches where pure turpentine is used, with the exception of medicinal purposes, for which we do not sell it.

We understand that if we were to sell any cotton-seed oil so branded as to indicate that it was intended to be used as a food, as, for example, under the brand "Blank Salad Oil," it would be necessary to observe the requirements of the law referred to; but we are in doubt and would be glad to have your opinion as to whether a sale or shipment of this oil (for lubricating purposes) under the ordinary trade brand of cotton-seed oil, and without anything to indicate that it was of a quality suitable for use as a salad oil, would subject us to the provisions of the act.

During personal interviews the question of marking chemical reagents has also been discussed.

Products used in the arts and for technical purposes are not subject to the food and drugs act. It is, however, a well-recognized fact that many articles are used indiscriminately for food, medicinal, and technical purposes. It is also well known that some products employed for technical purposes are adulterated or misbranded within the meaning of this act. Inasmuch as it is impossible to follow such products into consumption in order to determine to what use they are finally put, it is desirable that an article sold under a name commonly applied to such article for food, drug, and technical purposes be so labeled as to avoid possible mistakes. The ordinary name of a pure and normal product, whether sold for food, drug, technical, or other purposes, is all that is necessary. Pure cotton-seed oil or turpentine may be sold without any restrictions whatever, whether such article is sold for food, medicinal, or technical purposes, but it is suggested that a cotton-seed oil intended for lubricating purposes, or a so-called turpentine consisting of a mixture of turpentine and petroleum oils, used by the paint trade, be plainly marked so as to indicate that they are not to be employed for food or medicinal purposes. Such phrases as the following may be used: "Not for Food Purposes," "Not for Medicinal Use," or for "Technical Purposes Only," or "For Lubricating Purposes," etc.

In order to avoid complication it is suggested that chemical reagents sold as such be marked with such phrases as the following: "For Analytical Purposes," or "Chemical Reagent," etc.

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *March 13, 1907.*

FOOD INSPECTION DECISION 76

DYES, CHEMICALS, AND PRESERVATIVES IN FOODS

It is provided in regulation 15 of the rules and regulations for the enforcement of the food and drugs act, that the Secretary of Agriculture shall determine by chemical or other examination those substances which are permitted or inhibited in food products; that he shall determine from time to time the principles which shall guide the use of colors, preservatives, and other substances added to foods; and that when these findings and determinations of the Secretary of Agriculture are approved by the Secretary of the Treasury and the Secretary of Commerce and Labor, the principles so established shall become a part of the rules and regulations for the enforcement of the food and drugs act.

The law provides that no food or food product intended for interstate commerce, nor any food or food product manufactured or sold in the District of Columbia or in any Territory of the United States, or for foreign commerce, except as thereafter provided, shall contain substances which lessen the wholesomeness or which add any deleterious properties thereto. It has been determined that no drug, chemical, or harmful or deleterious dye or preservative may be used. Common salt, sugar, wood smoke, potable distilled liquors, vinegar, and condiments may be used. Pending further investigation, the use of saltpeter is allowed.

Pending the investigation of the conditions attending processes of manufacture, and the effects upon health, of the combinations mentioned in this paragraph, the Department of Agriculture will institute no prosecution in the case of the application of fumes of burning sulphur (sulphur dioxid), as usually employed in the manufacture of those foods and food products which contain acetaldehyde, sugars, etc., with which sulphurous acid may combine, if the total amount of sulphur dioxid in the finished product does not exceed 350 milligrams per liter in wines, or 350 milligrams per kilogram in other food products, of which not over 70 milligrams is in a free state.

The label of each package of sulphured foods, . . . shall bear a statement that the food is preserved with sulphur dioxid, . . . and the label must not bear a serial number assigned to any guaranty filed with the Department of Agriculture nor any statement that the article is guaranteed to conform to the food and drugs act.

The use of any dye, harmless or otherwise, to color or stain a food in a manner whereby damage or inferiority is concealed is specifically prohibited by law. The use in food for any purpose of any mineral dye or any coal-tar dye, except those coal-tar dyes hereinafter listed, will be grounds for prosecution. Pending further investigations now under way and the announcement thereof, the coal-tar dyes hereinafter named, made specifically for use in foods, and which bear a guaranty from the manufacturer that they are free from subsidiary products and represent the actual substance the name of which they bear, may be used in foods. In every case a certificate that the dye in question has been tested by competent experts and found to be free from harmful constituents must be filed with the Secretary of Agriculture and approved by him.

The following coal-tar dyes which may be used in this manner are given numbers, the numbers preceding the names referring to the number of the dye in question as listed in A. G. Green's

edition of the Schultz-Julius Systematic Survey of the Organic Coloring Matters, published in 1904.

The list is as follows:

Red shades:

- 107. Amaranth.
- 56. Ponceau 3 R.
- 517. Erythrosin.

Orange shade:

- 85. Orange I.

Yellow shade:

- 4. Naphthol yellow S.

Green shade:

- 435. Light green S. F. yellowish.

Blue shade:

- 692. Indigo disulfoacid.

Each of these colors shall be free from any coloring matter other than the one specified and shall not contain any contamination due to imperfect or incomplete manufacture. . . .

H. W. WILEY,
FREDERICK L. DUNLAP,
GEO. P. McCABE,

Board of Food and Drug Inspection.

Approved:

JAMES WILSON,
Secretary of Agriculture.

GEO. B. CORTELYOU,
Secretary of the Treasury.

OSCAR STRAUS,
Secretary of Commerce and Labor.

WASHINGTON, D. C., June 18, 1907.

FOOD INSPECTION DECISION 77

CERTIFICATE AND CONTROL OF DYES PERMISSIBLE FOR
USE IN COLORING FOODS AND FOODSTUFFS

The Department of Agriculture is in receipt of a large number of inquiries concerning the interpretation to be put on that portion of F. I. D. 76 which refers to coal-tar dyes not inhibited for use in coloring foods and foodstuffs.

The term "manufacturer," as used in F. I. D. 76 and in the present decision, applies to a person or company responsible for the purification of the crude or raw dye for the purpose of placing it in a condition fit for use in foods and foodstuffs; or to the accredited selling agent in the United States of such person or company. Such accredited agent must file, on behalf of his foreign principal, if the latter does not file it, a manufacturer's certificate, and it will be considered that the responsibility for such certificate will rest upon the accredited agent and not upon the foreign principal.

For each permitted dye two certificates must be filed by the manufacturer, the first to be known as the "Foundation certificate," the second known as the "Manufacturer's certificate." It is suggested that the foundation certificate be in the following form:

FOUNDATION CERTIFICATE

I,, the undersigned, residing at
(Street address.)
in the city of, county of, State
of, hereby certify under oath that I have personally
examined and tested for, of,
(Full name of concern.) (City.)
county of, State of, the
material known as, which corresponds to the coloring
matter numbered in A. G. Green's Edition (1904) of the Schultz-
Julius "Systematic Survey of the Organic Coloring Matters," and of which a
one (1) pound sample marked is herewith submitted. I have found

the said material to consist of that coloring matter only, to be free from harmful constituents, and not to contain any contamination due to imperfect or incomplete manufacture.

(Here insert a complete statement of all the tests applied to determine:

A. Identity.

B. Absence of

a. Mineral or metallic poisons.

b. Harmful organic constituents.

c. Contamination due to improper or incomplete manufacture.

Special attention should be given to setting forth fully the quantities or volume of each material and reagent employed, its strength or concentration, temperature, duration of treatment, limits of delicacy of tests employed, and any other information that is necessary to enable others to repeat accurately and correctly all the work herein referred to and thus arrive at identical results. For each test performed, state what conclusions are drawn from it and why.)

.....
(Signature of chemist making the examination.)

CERTIFICATION

For the manufacturer's certificate the following form is suggested:

MANUFACTURER'S CERTIFICATE

I,, the undersigned, a resident of the United States doing business at, in the city of,
(Street address.)

county of, State of, under the style of, do hereby certify under oath that I am
(Full name of concern.)

the manufacturer of the material known as, which corresponds to the coloring matter numbered in the 1904 Green Edition of the Schultz-Julius Tables, of which the accompanying foundation certificate, signed by, the examining chemist, is the report of an analysis of a fair, average sample drawn from a total batch of pounds.

.....
(Signature of manufacturer.)

CERTIFICATION.

The foundation certificate must be filed with the Secretary of Agriculture at the time the first request is made of the Secretary

to use any or all of the permitted dyes for coloring foods and foodstuffs.

The following form of supplemental certificate is suggested in those cases where a manufacturer desires to apply for permission to place on the market a new batch of a coal-tar dye, which dye has already had a foundation certificate and a manufacturer's certificate filed for it.

SUPPLEMENTAL CERTIFICATE

I,, the undersigned, residing at, (Street address.)
 in the city of, county of, State
 of, hereby certify under oath that I have personally
 examined and tested for, of,
 (Full name of concern.) (City.)
 county of, State of, the
 material known as, which corresponds to the coloring
 matter numbered in A. G. Green's Edition (1904) of the Schultz-
 Julius "Systematic Survey of the Organic Coloring Matters," of which a one
 (1) pound sample marked is herewith submitted, and I have found it
 to consist of that coloring matter only and to be free from harmful constitu-
 ents and not to contain any contamination due to imperfect or incomplete
 manufacture.

This examination was conducted in strict accordance with the detailed
 scheme of examination fully set forth in the foundation certificate filed

 (Date.)

.
 (Signature of chemist.)

CERTIFICATION.

This supplemental certificate should likewise be accompanied by the same type of manufacturer's certificate as is described above.

When the certificates filed with the Department of Agriculture are found to be satisfactory, a "lot number" will be assigned to each batch, which lot number shall apply to that batch alone and to no other batch of the same color.

According to F. I. D. 76, the seven permitted coal-tar dyes therein named, made specifically for use in foods, may be used in foods provided they bear a *guaranty* from the manufacturer that they are free from subsidiary products and represent the actual substance the name of which they bear. The guaranty herein considered shall be applied as follows:

Each package sold by the manufacturer should bear the legend "Part of Certified Lot Number" The foundation certificate, as well as the corresponding supplemental certificate, does not apply to any certified dye beyond the package originally prepared by the one establishing this certificate. If such a package be broken and the dye therein contained be repacked, the repacked dye, except as hereinafter provided, becomes an uncertified dye, and as such is inhibited.

There is no objection on the part of the Department of Agriculture to mixtures made from these permitted and certified dyes, by those who have filed certificates with the Department, but one (1) pound samples of such mixtures, and the trade name under which each mixture is sold, must be sent to the Secretary of Agriculture, and no such trade name or keyed modification thereof may be used for any other mixture.

The exact formula — that is, the true names as well as the numbers assigned to the original package and the proportions of the ingredients used — should be deposited with the Secretary of Agriculture, but such formula need not appear on the label; in lieu of which may appear the legend "Made from Certified Lots Number . . . and Number . . . ," etc. If the packages of these mixtures bearing this legend be broken and repacked, the mixture becomes, except as hereinafter provided, an uncertified one, and hence its use is inhibited; that is, the guaranty of the manufacturer shall extend only to the packages prepared by himself and only for so long as they remain in the unbroken form. Whenever new lots of previously established mixtures are made, making use of new certified straight dyes therein,

thus necessitating a change in the label, 1-pound samples of the new mixtures should be sent to the Secretary of Agriculture.

The term "competent experts" as used in F. I. D. 76 applies to those who, by reason of their training and experience, are able to examine coal-tar coloring matter to ascertain its identity and to determine the absence of foreign matter not properly belonging to the product, which, if present, renders the substance unfit for use in food products.

The term "batch" as used above is such a quantity of the product as has undergone the same treatment at the same time and the same place as a unit and not otherwise — that is, the lot for one purification.¹

Those to whom certification is given with respect to their dyes and a lot number assigned should control the sale of such batches so that they may account to the Department of Agriculture by inspection of their books or otherwise for the destination and disposal of each batch.

Those using these certified dyes in the preparation of foods and foodstuffs must be in a position to substantiate the fact that the dyes so used were of a properly certified character.

There is no guaranty on the part of the Department of Agriculture that because the tests described in any foundation certificate have once been accepted, the permanency of such acceptance is assured.

In those cases where a package of a straight dye or a mixture of such dyes, bearing proper labels to the effect that they are of a certified lot or lots, is broken and repacked in still smaller lots, or treated with solvents, mixed, etc., the person or company so treating these dyes must stand sponsor for their integrity. This may be accomplished by submitting a statement to the Secretary of Agriculture as follows:

¹ This definition is extended in Food Inspection Decision 106 (see below).

SECONDARY CERTIFICATE

I,, residing at, do hereby
 (Full address.)
 certify under oath that I have repacked lbs. of certified lot (or lots)
 purchased from, of
 This repacking has been accomplished in the following
 fashion:

 (Full description of what has been done with the lot or lots.)

 (Name.)

CERTIFICATION.

On presentation of this certified form, properly filled out, to the Secretary of Agriculture, a lot number will be assigned, which number should be used in labeling according to the methods already described. If, for example, a portion of lot number " 127 " is repacked in smaller packages, the lot number " 127 A " will be assigned to this repacked dye, to enable the Department to follow this into consumption if necessary and still trace it back to the person by whom the dye was originally certified.

H. W. WILEY,
 F. L. DUNLAP,
 GEO. P. McCABE,

Board of Food and Drug Inspection.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., September 16, 1907.

FOOD INSPECTION DECISION 106

AMENDMENT TO FOOD INSPECTION DECISION 77

(A definition of the terms " Batch " and " Mixtures " as used therein.)

The definition of the term " batch " as given on page 4, lines 12 to 14 of Food Inspection Decision 77, is hereby extended

to include also the contents of any one package, cask, or other container holding 500 pounds or less of dye, even though the contents of such package, cask, or container has not undergone the same treatment at the same time and the same place as a unit.

The word "mixtures" as used on page 3, line 15 from the bottom, and following, of Food Inspection Decision 77 is hereby declared to mean not only such mixtures as consist wholly of certified coal-tar dyes but also those which contain one or more certified coal-tar dyes (and no other coal-tar dye or dyes) in combination with other components, constituents, or ingredients not coal-tar dyes, which other components, constituents, or ingredients are in and of themselves or in the combination used harmless and not detrimental to health or are not prohibited for use in food products; the exact formula of such mixtures, including all of the components, constituents, or ingredients, or other parts of the mixture, together with a statement of the total weight of mixture so made, must be deposited with the Secretary of Agriculture and a one (1) pound sample thereof must be sent to the Secretary of Agriculture, but such formula need not appear on the label; in lieu of which may appear the legend "Made from certified lots Number . . . and Number . . . , etc.," and no mention need be made of any constituent or constituents other than of the certified coal-tar dyes employed.

H. W. WILEY,

F. L. DUNLAP,

GEO. P. McCABE,

Board of Food and Drug Inspection.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., March 19, 1909.

FOOD INSPECTION DECISION 126

SALTS OF TIN IN FOOD

The attention of the board has been directed to canned goods which contain salts of tin derived from the solvent action of the contents of the package upon the tin coating. Pending further investigations on this question all canned goods which are prepared prior to January 1, 1911, will be permitted to enter and pass into interstate commerce without detention or restriction in so far as their content of tin salts is concerned. All foods which are canned subsequently to January 1, 1911, will be permitted importation and interstate commerce if they do not contain more than 300 milligrams of tin per kilogram, or salts of tin equivalent thereto. When the amount of tin, or an equivalent amount of salts of tin, is greater than 300 milligrams per kilogram, entry of such canned goods packed subsequently to January 1, 1911, will be refused, and if found in interstate commerce proper action will be taken.

It is the opinion of the board that the trade will experience little hardship in adjusting itself to this condition, as the results of examinations made by the Bureau of Chemistry of various types of canned goods indicate that in a very large majority of cases inconsiderable quantities of tin are found, well within the limit herein set.

H. W. WILEY,
F. L. DUNLAP,
Geo. P. McCABE,

Board of Food and Drug Inspection.

Approved:

JAMES WILSON,
Secretary of Agriculture,

WASHINGTON, D. C., *September 22, 1910.*

FOOD INSPECTION DECISION 129

THE CERTIFICATION OF STRAIGHT DYES AND MIXTURES
UNDER SECONDARY CERTIFICATES. (AMENDMENT TO
F. I. D. 77.)

In Food Inspection Decision 77 provision is made for the recertification of straight dyes (*i.e.*, the seven accepted dyes of F. I. D. 76) and mixtures thereof, with or without other harmless ingredients.

Doubt has been expressed as to whether the requirements of F. I. D. 77, with respect to certification, are the same for those who are not manufacturers as they are for manufacturers. This amendment is issued relative to recertification in order to remove uncertainty and to indicate the scope of F. I. D. 77.

All persons, manufacturers or others, requesting certification of mixtures or recertification of straight dyes, or of mixtures or combinations thereof, shall submit the following form of secondary certificate to the Secretary of Agriculture:

SECONDARY CERTIFICATE

I,, residing at, do hereby depose and state
(Full address.)

that I have repacked lbs. of certified lot (or lots) purchased from
....., of

This repacking has been accomplished in the following fashion:

.....
(Full description of what has been done with the lot or lots.)

Certified mixture No. J.D. & Co., or certified straight dye No. J. D.
& Co.

Trade name

.....
(Name.)

Subscribed and sworn to before me,, in and for the
of at, this day of,

.....
(Name of officer authorized to administer oaths.)

When the secondary certificate refers to mixtures, the term "mixture" means —

not only such mixtures as consist wholly of certified coal-tar dyes, but also those which contain one or more certified coal-tar dyes (and no other coal-tar dye or dyes) in combination with other components, constituents, or ingredients not coal-tar dyes, which other components, constituents, or ingredients are in and of themselves or in the combination used harmless and not detrimental to health or are not prohibited for use in food products; the exact formula of such mixtures, including all of the components, constituents, or ingredients, or other parts of the mixture, together with a statement of the total weight of mixtures so made, must be deposited with the Secretary of Agriculture. (F. I. D. 106.)

The term "straight dye," as used herein, refers to the seven dyes specified in F. I. D. 76.

In the case of mixtures one (1) pound samples, and in the case of straight dyes one half ($\frac{1}{2}$) pound samples must be submitted with the secondary certificate. If larger samples are needed in individual cases the Department will ask for them.

Only those mixtures will be certified which contain no other dyes than coal-tar dyes previously certified. Mixtures containing animal or vegetable dyes are not subject to certification.

The above form for secondary certificates varies but slightly from that given in Food Inspection Decision No. 77. It contains the addition "Certified mixture No. J. D. & Co. . . ." and "Certified straight dye No. J. D. & Co. . . ." When the manufacturer or other person submits a secondary certificate, whichever legend is appropriate to the certificate is to be used. The initials are to be those of the person or firm filing the certificate; the blank space is to be filled with the number of the secondary certificate filed by that particular person or firm. For example, the firm of J. D. & Co. has already filed fourteen secondary certificates, the new one to be filed under the form given above will then be labeled "Certified mixture No. J. D. & Co. 15," or "Certified straight dye No. J. D. & Co. 15," as the case may be. That is, the recertified straight dyes or

certified mixtures are to be given a number in regular order, according to the number of such secondary certificates filed by any person or firm. The completed legend is the one to be used in marketing the products thus submitted under the secondary certificate. Notification will be given of the acceptance or rejection of the certificate when investigation of the product has been completed.

Makers of secondary certificates must submit the trade name of mixtures produced, and no such trade name or keyed modification thereof should be used on any other mixture prepared by the same person or company.

Secondary certificates are to be sent in duplicate to the Department of Agriculture; the duplicate need not, however, be signed or sworn to. The samples should be submitted with the secondary certificates.

H. W. WILEY,
F. L. DUNLAP,
GEO. P. McCABE,

Board of Food and Drug Inspection.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., November 8, 1910.

FOOD INSPECTION DECISION 135

SACCHARIN IN FOOD

At the request of the Secretary of Agriculture, the Referee Board of Consulting Scientific Experts has conducted an investigation as to the effect on health of the use of saccharin. The investigation has been concluded, and the Referee Board reports that the continued use of saccharin for a long time in quantities over three tenths of a gram per day is liable to impair digestion; and that the addition of saccharin as a substitute

for cane sugar or other forms of sugar reduces the food value of the sweetened product and hence lowers its quality.

Saccharin has been used as a substitute for sugar in over thirty classes of foods in which sugar is commonly recognized as a normal and valuable ingredient. If the use of saccharin be continued it is evident that amounts of saccharin may readily be consumed which will, through continual use, produce digestive disturbances. In every food in which saccharin is used, some other sweetening agent known to be harmless to health can be substituted, and there is not even a pretense that saccharin is a necessity in the manufacture of food products. Under the food and drugs act articles of food are adulterated if they contain added poisonous or other added deleterious ingredients which may render them injurious to health. Articles of food are also adulterated within the meaning of the act, if substances have been mixed and packed with the foods so as to reduce or lower or injuriously affect their quality or strength. The findings of the Referee Board show that saccharin in food is such an added poisonous or other added deleterious ingredient as is contemplated by the act, and also that the substitution of saccharin for sugar in foods reduces and lowers their quality.

The Secretary of Agriculture, therefore, will regard as adulterated under the food and drugs act foods containing saccharin which, on and after July 1, 1911, are manufactured or offered for sale in the District of Columbia or the Territories, or shipped in interstate or foreign commerce, or offered for importation into the United States.

FRANKLIN MACVEAGH,
Secretary of the Treasury.

JAMES WILSON,
Secretary of Agriculture.

CHARLES NAGEL,
Secretary of Commerce and Labor.

WASHINGTON, D. C., *April 26, 1911.*

FOOD INSPECTION DECISION 138

SACCHARIN IN FOOD

Paragraph 3 of Food Inspection Decision No. 135 is hereby modified to read as follows:

The Secretary of Agriculture, therefore, will regard as adulterated under the food and drugs act foods containing saccharin which, on and after January 1, 1912, are manufactured or offered for sale in the District of Columbia or the Territories, or shipped in interstate or foreign commerce, or offered for importation into the United States.

FRANKLIN MACVEAGH,
Secretary of the Treasury.

JAMES WILSON,
Secretary of Agriculture.

CHARLES NAGEL,
Secretary of Commerce and Labor.

WASHINGTON, D. C., *June 20, 1911.*

FOOD INSPECTION DECISION 142

SACCHARIN IN FOOD

The following decision which relates to the use of saccharin in food will not go into effect until the 1st of April, 1912, the month of March being given to interested parties so as to arrange their business and take such steps as they deem proper.

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *March 1, 1912.*

After full consideration of the representations made in behalf of the manufacturers of saccharin at the hearing before us and of the briefs filed by their attorneys, as well as the briefs filed, at our request, by officers of the Department of Agriculture, we conclude that the use of saccharin in normal foods, within the

jurisdiction of the Food and Drugs Act, is a violation of law and will be prosecuted.

It is true that the Referee Board did not find that the use in foods of saccharin in small quantities (up to 0.3 gram daily) is injurious to health. However, the Referee Board did find that saccharin used in quantities over 0.3 gram per day for a considerable period is liable to disturb digestion, and the Food and Drugs Act provides that articles of food are adulterated which contain any added poisonous or other added deleterious ingredient which may render them injurious to health.

The Bureau of Chemistry of the Department of Agriculture reports that saccharin has been found in more than fifty kinds of foods in common use. It is argued, therefore, that if the use of saccharin in foods be allowed, the consumer may very easily ingest, day by day, over 0.3 gram, the quantity which, according to the findings of the Referee Board, is liable to produce disturbances of digestion. On the other hand, it is claimed by the manufacturers that the sweetening power of saccharin is so great that, in a normal dietary, the amount of saccharin ingested daily would not exceed 0.3 gram, the amount found to be harmless by the Referee Board.

However this may be, it is plain, from the finding of the Referee Board, that the substitution of saccharin for sugar lowers the quality of the food. The only use of saccharin in foods is as a sweetener, and when it is so used, it inevitably displaces the sugar of an equivalent sweetening power. Sugar has a food value and saccharin has none. It appears, therefore, that normal foods sweetened with saccharin are adulterated under the law.

In making this decision we are not unmindful of the fact that persons suffering from certain diseases may be directed by their physicians to abstain from the use of sugar. In cases of this kind, saccharin is often prescribed as a substitute sweetening agent. This decision will not in any manner interfere with

such a use of saccharin. The Food and Drugs Act provides that any substance which is intended to be used for the prevention, cure, or mitigation of disease is a drug, and a product containing saccharin and plainly labeled to show that the mixture is intended for the use of those persons who, on account of disease, must abstain from the use of sugar, falls within the class of drugs and is not affected by this decision.

The Secretary of the Treasury dissents.

JAMES WILSON,
Secretary of Agriculture.

CHARLES NAGEL,
Secretary of Commerce and Labor.

WASHINGTON, D. C., *February 29, 1912.*

FOOD INSPECTION DECISION 144

CANNED FOODS: USE OF WATER, BRINE, SIRUP, SAUCE, AND SIMILAR SUBSTANCES IN THE PREPARATION THEREOF

The can in canned food products serves not only as a container but also as an index of the quantity of food therein. It should be as full of food as is practicable for packing and processing without injuring the quality or appearance of the contents. Some food products may be canned without the addition of any other substances whatsoever — for example, tomatoes. The addition of water in such instances is deemed adulteration. Other foods may require the addition of water, brine, sugar, or sirup, either to combine with the food for its proper preparation or for the purpose of sterilization — for instance, peas. In this case the can should be packed as full as practicable with the peas and should contain only sufficient liquor to fill the interstices and cover the product.

Canned foods, therefore, will be deemed to be adulterated if they are found to contain water, brine, sirup, sauce, or similar

substances in excess of the amount necessary for their proper preparation and sterilization.

It has come to the notice of the department that pulp prepared from trimmings, cores, and other waste material is sometimes added to canned tomatoes. It is the opinion of the board that pulp is not a normal ingredient of canned tomatoes, and such addition is therefore adulteration. It is the further opinion of the board that the addition of tomato juice in excess of the amount present in the tomatoes used is adulteration — that is, if in the canning of a lot of tomatoes more juice be added than is present in that lot, the same will be considered an adulteration.

R. E. DOOLITTLE,

A. S. MITCHELL,

Board of Food and Drug Inspection.

Approved :

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., May 22, 1912.

FOOD INSPECTION DECISION 146

ON THE USE OF SACCHARIN IN FOODS

There appears to exist a misconception of the position of the Department of Agriculture as to the use of saccharin in foods as announced in Food Inspection Decision No. 142. That decision prohibits the use of saccharin in foods. The law defines the term "drug" and it is considered that saccharin has its proper place in products coming within this definition.

It is recognized that certain specific products generally classified as foods, and sweetened with saccharin, may be required for the mitigation or cure of disease. It is not intended to prohibit the manufacture or sale of such products, provided

they are labeled so as to show their true purpose and the presence of saccharin is plainly declared upon the principal label. This must not be interpreted to mean that the use of saccharin in foods prepared for ordinary consumption is permissible even if declared on the label.

R. E. DOOLITTLE,

F. L. DUNLAP,

A. S. MITCHELL,

Board of Food and Drug Inspection.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., June 22, 1912.

FOOD INSPECTION DECISION 153

AMENDMENT TO REGULATION 9, RELATING TO GUARANTIES BY WHOLESALERS, JOBBERS, MANUFACTURERS, AND OTHER PARTIES RESIDING IN THE UNITED STATES TO PROTECT DEALERS FROM PROSECUTION

Regulation 9 of the Rules and Regulations for the enforcement of the Food and Drugs Act, June 30, 1906 (34 Stat., 768), is hereby amended, effective May 1, 1915, so as to read as follows:

REGULATION 9. GUARANTY

(Section 9.)

(a) It having been determined that the legends "Guaranteed under the Food and Drugs Act, June 30, 1906," and "Guaranteed by (name of guarantor), under the Food and Drugs Act, June 30, 1906," borne on the labels or packages of food and drugs, accompanied by serial numbers given by the Secretary of Agriculture, are each misleading and deceptive, in that the public is induced by such legends and serial numbers to believe that

the articles to which they relate have been examined and approved by the Government and that the Government guarantees that they comply with the law, the use of either legend, or any similar legend, on labels or packages should be discontinued. Inasmuch as the acceptance by the Secretary of Agriculture for filing of the guaranties of manufacturers and dealers and the giving by him of serial numbers thereto contribute to the deceptive character of legends on labels and packages, no guaranty in any form shall hereafter be filed with and no serial number shall hereafter be given to any guaranty by the Secretary of Agriculture. All guaranties now on file with the Secretary of Agriculture shall be stricken from the files, and the serial numbers assigned to such guaranties shall be canceled.

(b) The use on the label or package of any food or drug of any serial number required to be canceled by paragraph (a) of this regulation is prohibited.

(c) Any wholesaler, manufacturer, jobber, or other party residing in the United States may furnish to any dealer to whom he sells any article of food or drug a guaranty that such article is not adulterated or misbranded within the meaning of the Food and Drugs Act, June 30, 1906, as amended.

(d) Each guaranty to afford protection shall be signed by, and shall contain the name and address of, the wholesaler, manufacturer, jobber, dealer, or other party residing in the United States making the sale of the article or articles covered by it to the dealer, and shall be to the effect that such article or articles are not adulterated or misbranded within the meaning of the Federal Food and Drugs Act.

(e) Each guaranty in respect to any article or articles should be incorporated in or attached to the bill of sale, invoice, bill of lading, or other schedule, giving the names and quantities of the article or articles sold, and should not appear on the labels or packages.

(f) No dealer in food or drug products will be liable to pros-

ecution if he can establish that the articles were sold under a guaranty given in compliance with this regulation.

W. G. McADOO,
Secretary of the Treasury.

D. F. HOUSTON,
Secretary of Agriculture.

WILLIAM C. REDFIELD,
Secretary of Commerce.

WASHINGTON, D. C., May 5, 1914.

FOOD INSPECTION DECISION 154

REGULATION OF MARKING THE QUANTITY OF FOOD IN PACKAGE FORM

Under section 3 of the Food and Drugs Act of June 30, 1906 (34 United States Statutes at Large, pages 768 to 772), as amended by the Act of March 3, 1913, entitled "An Act to amend section eight of an Act entitled 'An Act for preventing the manufacture, sale, or transportation of adulterated or misbranded or poisonous or deleterious foods, drugs, medicines, and liquors, and for regulating traffic therein, and for other purposes,' approved June thirtieth, nineteen hundred and six" (37 United States Statutes at Large, page 732), Regulation 29 of the Rules and Regulations for the Enforcement of the Food and Drugs Act is hereby amended so as to read as follows:

STATEMENT OF WEIGHT, MEASURE, OR COUNT

(Section 8, paragraph 3, under "Food," as amended by act of March 3, 1913.)

(a) Except as otherwise provided by this regulation, the quantity of the contents, in all cases of food, if in package form, must be plainly and conspicuously marked, in terms of weight, measure, or numerical count, on the outside of the covering or container usually delivered to consumers.

(b) The quantity of the contents so marked shall be the amount of food in the package.

(c) The statement of the quantity of the contents shall be plain and conspicuous, shall not be a part of or obscured by any legend or design, and shall be so placed and in such characters as to be readily seen and clearly legible when the size of the package and the circumstances under which it is ordinarily examined by purchasers or consumers are taken into consideration.

(d) If the quantity of the contents be stated by weight or measure, it shall be marked in terms of the largest unit contained in the package; for example, if the package contain a pound, or pounds, and a fraction of a pound, the contents shall be expressed in terms of pounds and fractions thereof; or of pounds and ounces, and not merely in ounces.

(e) Statements of weight shall be in terms of avoirdupois pounds and ounces; statements of liquid measure shall be in terms of the United States gallon of 231 cubic inches and its customary subdivisions, *i.e.*, in gallons, quarts, pints, or fluid ounces, and shall express the volume of the liquid at 68° F. (20° C.); and statements of dry measure shall be in terms of the United States standard bushel of 2,150.42 cubic inches and its customary subdivisions, *i.e.*, in bushels, half bushels, pecks, quarts, pints, or half pints: *Provided*, That, by like method, such statements may be in terms of metric weight or measure.

(f) The quantity of solids shall be stated in terms of weight and of liquids in terms of measure, except that in case of an article in respect to which there exists a definite trade custom otherwise, the statement may be in terms of weight or measure in accordance with such custom. The quantity of viscous or semi-solid foods, or of mixtures of solids and liquids, may be stated either by weight or measure, but the statement shall be definite and shall indicate whether the quantity is expressed in terms of weight or measure as, for example, "Weight 12 oz.,"

or " 12 oz. avoirdupois "; " Volume 12 ounces," or " 12 fluid ounces."

(g) The quantity of the contents shall be stated in terms of weight or measure unless the package be marked by numerical count and such numerical count gives accurate information as to the quantity of the food in the package.

(h) The quantity of the contents may be stated in terms of minimum weight, minimum measure, or minimum count, for example, " minimum weight 16 oz.," " minimum volume 1 gallon," or " not less than 4 oz.;" but in such case the statement must approximate the actual quantity and there shall be no tolerance below the stated minimum.

(i) The following tolerances and variations from the quantity of the contents marked on the package shall be allowed :

(1) Discrepancies due exclusively to errors in weighing, measuring, or counting which occur in packing conducted in compliance with good commercial practice.

(2) Discrepancies due exclusively to differences in the capacity of bottles and similar containers resulting solely from unavoidable difficulties in manufacturing such bottles or containers so as to be of uniform capacity : *Provided*, That no greater tolerance shall be allowed in case of bottles or similar containers which, because of their design, cannot be made of approximate uniform capacity than is allowed in case of bottles or similar containers which can be manufactured so as to be of approximate uniform capacity.

(3) Discrepancies in weight or measure, due exclusively to differences in atmospheric conditions in various places, and which unavoidably result from the ordinary and customary exposure of the packages to evaporation or to the absorption of water.

Discrepancies under classes (1) and (2) of this paragraph shall be as often above as below the marked quantity. The reasonableness of discrepancies under class (3) of this paragraph will be determined on the facts in each case.

(j) A package containing two avoirdupois ounces of food or less is "small" and shall be exempt from marking in terms of weight.

(k) A package containing one fluid ounce of food or less is "small" and shall be exempt from marking in terms of measure.

(l) When a package is not required by paragraph (g) to be marked in terms of either weight or measure, and the units of food therein are six or less, it shall, for the purpose of this regulation, be deemed "small" and shall be exempt from marking in terms of numerical count.

W. G. McADOO,
Secretary of the Treasury.

D. F. HOUSTON,
Secretary of Agriculture.

WILLIAM C. REDFIELD,
Secretary of Commerce.

WASHINGTON, D. C., May 11, 1914.

FOOD INSPECTION DECISION 155

CHANGING EFFECTIVE DATE OF FOOD INSPECTION DECISION NO. 153, WHICH AMENDS REGULATION 9, RELATING TO GUARANTIES BY WHOLESALERS, JOBBERS, MANUFACTURERS, AND OTHER PARTIES RESIDING IN THE UNITED STATES, TO PROTECT DEALERS FROM PROSECUTION

The effective date of Food Inspection Decision No. 153, issued May 5, 1914, is hereby postponed until May 1, 1916: *Provided*, That as to products packed and labeled prior to May 1, 1916, in accordance with law and with the regulations in force prior to May 5, 1914, it shall become effective November 1, 1916; *And provided further*, That compliance with the terms of Regulation 9 of the Rules and Regulations for the enforce-

ment of the Food and Drugs Act as amended by Food Inspection Decision No. 153 will be permitted at any time after the date of this decision.

C. S. HAMLIN,

Acting Secretary of the Treasury.

D. F. HOUSTON,

Secretary of Agriculture.

WILLIAM C. REDFIELD,

Secretary of Commerce.

WASHINGTON, D. C., May, 29, 1914.

APPENDIX C

METHODS AND STANDARDS FOR THE PRODUCTION AND DISTRIBUTION OF CERTIFIED MILK

(Adopted by the American Association of Medical Milk Commissions, May 1, 1912.)

HYGIENE OF THE DAIRY

UNDER THE SUPERVISION AND CONTROL OF THE VETERINARIAN

1. *Pastures or paddocks.* Pastures or paddocks to which the cows have access shall be free from marshes or stagnant pools, crossed by no stream which might become dangerously contaminated, at sufficient distances from offensive conditions to suffer no bad effects from them, and shall be free from plants which affect the milk deleteriously.

2. *Surroundings of buildings.* The surroundings of all buildings shall be kept clean and free from accumulations of dirt, rubbish, decayed vegetable or animal matter or animal waste, and the stable yard shall be well drained.

3. *Location of buildings.* Buildings in which certified milk is produced and handled shall be so located as to insure proper shelter and good drainage, and at sufficient distance from other buildings, dusty roads, cultivated and dusty fields, and all other possible sources of contamination; provided, in the case of unavoidable proximity to dusty roads or fields, the exposed side shall be screened with cheesecloth.

4. *Construction of stables.* The stables shall be constructed so as to facilitate the prompt and easy removal of waste products. The floors and platforms shall be made of cement or other nonabsorbent material and the gutters of cement only. The floors shall be properly graded and drained, and the manure gutters shall be from 6 to 8 inches deep and so placed in relation to the platform that all manure will drop into them.

5. The inside surface of the walls and all interior construction shall be smooth, with tight joints, and shall be capable of shedding water. The ceiling shall be of smooth material and dust tight. All horizontal and slanting surfaces which might harbor dust shall be avoided.

6. *Drinking and feed troughs.* Drinking troughs or basins shall be drained and cleaned each day, and feed troughs and mixing floors shall be kept in a clean and sanitary condition.

7. *Stanchions.* Stanchions, when used, shall be constructed of iron pipes or hard wood, and throat latches shall be provided to prevent the cows from lying down between the time of cleaning and the time of milking.

8. *Ventilation.* The cow stables shall be provided with adequate ventilation either by means of some approved artificial device, or by the substitution of cheesecloth for glass in the windows, each cow to be provided with a minimum of 600 cubic feet of air space.

9. *Windows.* A sufficient number of windows shall be installed and so distributed as to provide satisfactory light and a maximum of sunshine, 2 feet square of window area to each 600 cubic feet of air space to represent the minimum. The coverings of such windows shall be kept free from dust and dirt.

10. *Exclusion of flies, etc.* All necessary measures should be taken to prevent the entrance of flies and other insects and rats and other vermin into all the buildings.

11. *Exclusion of animals from the herd.* No horses, hogs, dogs, or other animals or fowls shall be allowed to come in contact with the certified herd, either in the stables or elsewhere.

12. *Bedding.* No dusty or moldy hay or straw, bedding from horse stalls, or other unclean materials shall be used for bedding the cows. Only bedding which is clean, dry, and absorbent may be used, preferably shavings or straw.

13. *Cleaning stable and disposal of manure.* Soiled bedding and manure shall be removed at least twice daily, and the floors shall be swept and kept free from refuse. Such cleaning shall be done at least one hour before the milking time. Manure, when removed, shall be drawn to the field or temporarily stored in containers so screened as to exclude flies. Manure shall not be even temporarily stored within 300 feet of the barn or dairy building.

14. *Cleaning of cows.* Each cow in the herd shall be groomed daily, and no manure, mud, or filth shall be allowed to remain upon her during milking; for cleaning, a vacuum apparatus is recommended.

15. *Clipping.* Long hairs shall be clipped from the udder and flanks of the cow and from the tail above the brush. The hair on the tail shall be cut so that the brush may be well above the ground.

16. *Cleaning of udders.* The udders and teats of the cow shall be cleaned before milking; they shall be washed with a cloth and water, and dry wiped with another clean sterilized cloth — a separate cloth for drying each cow.

17. *Feeding.* All foodstuffs shall be kept in an apartment separate from

and not directly communicating with the cow barn. They shall be brought into the barn only immediately before the feeding hour, which shall follow the milking.

18. Only those foods shall be used which consist of fresh, palatable, or nutritious materials, such as will not injure the health of the cows or unfavorably affect the taste or character of the milk. Any dirty or moldy food or food in a state of decomposition or putrefaction shall not be given.

19. A well-balanced ration shall be used, and all changes of food shall be made slowly. The first few feedings of grass, alfalfa, ensilage, green corn, or other green feeds shall be given in small rations and increased gradually to full ration.

20. *Exercise.* All dairy cows shall be turned out for exercise at least 2 hours in each 24 in suitable weather. Exercise yards shall be kept free from manure and other filth.

21. *Washing of hands.* Conveniently located facilities shall be provided for the milkers to wash in before and during milking.

22. The hands of the milkers shall be thoroughly washed with soap, water, and brush and carefully dried on a clean towel immediately before milking. The hands of the milkers shall be rinsed with clean water and carefully dried before milking each cow. The practice of moistening the hands with milk is forbidden.

23. *Milking clothes.* Clean overalls, jumper, and cap shall be worn during milking. They shall be washed or sterilized each day and used for no other purpose, and when not in use they shall be kept in a clean place, protected from dust and dirt.

24. *Things to be avoided by milkers.* While engaged about the dairy or in handling the milk employees shall not use tobacco nor intoxicating liquors. They shall keep their fingers away from their nose and mouth, and no milker shall permit his hands, fingers, lips, or tongue to come in contact with milk intended for sale.

25. During milking the milkers shall be careful not to touch anything but the clean top of the milking stool, the milk pail, and the cow's teats.

26. Milkers are forbidden to spit upon the walls or floors of stables, or upon the walls or floors of milk houses, or into the water used for cooling the milk or washing the utensils.

27. *Fore milk.* The first streams from each teat shall be rejected, as this fore milk contains large numbers of bacteria. Such milk shall be collected into a separate vessel and not milked onto the floors or into the gutters. The milking shall be done rapidly and quietly, and the cows shall be treated kindly.

28. *Milk and calving period.* Milk from all cows shall be excluded for a period of 45 days before and 7 days after parturition.

29. *Bloody and stringy milk.* If milk from any cow is bloody and stringy or of unnatural appearance, the milk from that cow shall be rejected and the cow isolated from the herd until the cause of such abnormal appearance has been determined and removed, special attention being given in the meantime to the feeding or to possible injuries. If dirt gets into the pail, the milk shall be discarded and the pail washed before it is used.

30. *Make-up of herd.* No cows except those receiving the same supervision and care as the certified herd shall be kept in the same barn or brought in contact with them.

31. *Employees other than milkers.* The requirements for milkers, relative to garments and cleaning of hands, shall apply to all other persons handling the milk, and children unattended by adults shall not be allowed in the dairy nor in the stable during milking.

32. *Straining and strainers.* Promptly after the milk is drawn it shall be removed from the stable to a clean room and then emptied from the milk pail to the can, being strained through strainers made of a double layer of finely meshed cheesecloth or absorbent cotton thoroughly sterilized. Several strainers shall be provided for each milking in order that they may be frequently changed.

33. *Dairy building.* A dairy building shall be provided which shall be located at a distance from the stable and dwelling prescribed by the local commission, and there shall be no hogpen, privy, or manure pile at a higher level or within 300 feet of it.

34. The dairy building shall be kept clean and shall not be used for purposes other than the handling and storing of milk and milk utensils. It shall be provided with light and ventilation, and the floors shall be graded and water-tight.

35. The dairy building shall be well lighted and screened and drained through well-trapped pipes. No animals shall be allowed therein. No part of the dairy building shall be used for dwelling or lodging purposes, and the bottling room shall be used for no other purpose than to provide a place for clean milk utensils and for handling the milk. During bottling this room shall be entered only by persons employed therein. The bottling room shall be kept scrupulously clean and free from odors.

36. *Temperature of milk.* Proper cooling to reduce the temperature to 45° F. shall be used, and aerators shall be so situated that they can be protected from flies, dust, and odors. The milk shall be cooled immediately after being milked, and maintained at a temperature between 35° and 45° F. until delivered to the consumer.

37. *Sealing of bottles.* Milk, after being cooled and bottled, shall be immediately sealed in a manner satisfactory to the commission, but such

seal shall include a sterile hood which completely covers the lip of the bottle.

38. *Cleaning and sterilizing of bottles.* The dairy building shall be provided with approved apparatus for the cleansing and sterilizing of all bottles and utensils used in milk production. All bottles and utensils shall be thoroughly cleaned by hot water and sal soda, or equally pure agent, rinsed until the cleaning water is thoroughly removed, then exposed to live steam or boiling water at least 20 minutes, and then kept inverted until used, in a place free from dust and other contaminating materials.

39. *Utensils.* All utensils shall be so constructed as to be easily cleaned. The milk pail should preferably have an elliptical opening 5 by 7 inches in diameter. The cover of this pail should be so convex as to make the entire interior of the pail visible and accessible for cleaning. The pail shall be made of heavy seamless tin, and with seams which are flushed and made smooth by solder. Wooden pails, galvanized-iron pails, or pails made of rough, porous materials, are forbidden. All utensils used in milking shall be kept in good repair.

40. *Water supply.* The entire water supply shall be absolutely free from contamination, and shall be sufficient for all dairy purposes. It shall be protected against flood or surface drainage, and shall be conveniently situated in relation to the milk house.

41. *Privies, etc., in relation to water supply.* Privies, pigpens, manure piles, and all other possible sources of contamination shall be so situated on the farm as to render impossible the contamination of the water supply, and shall be so protected by use of screens and other measures as to prevent their becoming breeding grounds for flies.

42. *Toilet rooms.* Toilet facilities for the milkers shall be provided and located outside of the stable or milk house. These toilets shall be properly screened, shall be kept clean, and shall be accessible to wash basins, water, nail brush, soap, and towels, and the milkers shall be required to wash and dry their hands immediately after leaving the toilet room.

TRANSPORTATION

43. In transit the milk packages shall be kept free from dust and dirt. The wagon, trays, and crates shall be kept scrupulously clean. No bottles shall be collected from houses in which communicable diseases prevail, unless a separate wagon is used and under conditions prescribed by the department of health and the medical milk commission.

44. All certified milk shall reach the consumer within 30 hours after milking.

VETERINARY SUPERVISION OF THE HERD

45. *Tuberculin test.* The herd shall be free from tuberculosis, as shown by the proper application of the tuberculin test. The test shall be applied in accordance with the rules and regulations of the United States Government, and all reactors shall be removed immediately from the farm.¹

46. No new animals shall be admitted to the herd without first having passed a satisfactory tuberculin test, made in accordance with the rules and regulations mentioned; the tuberculin to be obtained and applied only by the official veterinarian of the commission.

47. Immediately following the application of the tuberculin test to a herd for the purpose of eliminating tuberculous cattle, the cow stable and exercising yards shall be disinfected by the veterinary inspector in accordance with the rules and regulations of the United States Government.

48. A second tuberculin test shall follow each primary test after an interval of six months, and shall be applied in accordance with the rules and regulations mentioned. Thereafter, tuberculin tests shall be reapplied annually, but it is recommended that the retests be applied semiannually.

49. *Identification of cows.* Each dairy cow in each of the certified herds shall be labelled or tagged with a number or mark which will permanently identify her.

50. *Herd-book record.* Each cow in the herd shall be registered in a herd book, which register shall be accurately kept so that her entrance and departure from the herd and her tuberculin testing can be identified.

51. A copy of this herd-book record shall be kept in the hands of the veterinarian of the medical milk commission under which the dairy farm is operating, and the veterinarian shall be made responsible for the accuracy of this record.

52. *Dates of tuberculin tests.* The dates of the annual tuberculin tests shall be definitely arranged by the medical milk commission, and all of the results of such tests shall be recorded by the veterinarian and regularly reported to the secretary of the medical milk commission issuing the certificate.

53. The results of all tuberculin tests shall be kept on file by each medical milk commission, and a copy of all such tests shall be made available to the American Association of Medical Milk Commissions for statistical purposes.

54. The proper designated officers of the American Association of Medical Milk Commissions should receive copies of reports of all of the annual, semi-annual, and other official tuberculin tests which are made and keep copies of the same on file and compile them annually for the use of the association.

¹ See Circular of Instructions issued by the Bureau of Animal Industry for making tuberculin tests and for disinfection of premises.

55. *Disposition of cows sick with diseases other than tuberculosis.* Cows having rheumatism, leucorrhea, inflammation of the uterus, severe diarrhea, or disease of the udder, or cows that from any other cause may be a menace to the herd shall be removed from the herd and placed in a building separate from that which may be used for the isolation of cows with tuberculosis, unless such building has been properly disinfected since it was last used for this purpose. The milk from such cows shall not be used nor shall the cows be restored to the herd until permission has been given by the veterinary inspector after a careful physical examination.

56. *Notification of veterinary inspector.* In the event of the occurrence of any of the diseases just described between the visits of the veterinary inspector, or if at any time a number of cows become sick at one time in such a way as to suggest the outbreak of a contagious disease or poisoning, it shall be the duty of the dairyman to withdraw such sickened cattle from the herd, to destroy their milk, and to notify the veterinary inspector by telegraph or telephone immediately.

57. *Emaciated cows.* Cows that are emaciated from chronic diseases or from any cause that in the opinion of the veterinary inspector may endanger the quality of the milk shall be removed from the herd.

BACTERIOLOGICAL STANDARDS

58. *Bacterial counts.* Certified milk shall contain less than 10,000 bacteria per cubic centimeter when delivered. In case a count exceeding 10,000 bacteria per cubic centimeter is found, daily counts shall be made, and if normal counts are not restored within 10 days the certificate shall be suspended.

59. Bacterial counts shall be made at least once a week.

60. *Collection of samples.* The samples to be examined shall be obtained from milk as offered for sale and shall be taken by a representative of the milk commission. The samples shall be received in the original packages, in properly iced containers, and they shall be so kept until examined, so as to limit as far as possible changes in their bacterial content.

61. For the purpose of ascertaining the temperature, a separate original package shall be used, and the temperature taken at the time of collecting the sample, using for the purpose a standardized thermometer graduated in the centigrade scale.

62. *Interval between milking and plating.* The examinations shall be made as soon after collection of the samples as possible, and in no case shall the interval between milking and plating the samples be longer than 40 hours.

63. *Plating.* The packages shall be opened with aseptic precautions after the milk has been thoroughly mixed by vigorously reversing and shaking the container 25 times.

64. Two plates at least shall be made for each sample of milk, and there shall also be made a control of each lot of medium and apparatus used at each testing. The plates shall be grown at 37° C. for 48 hours.

65. In making the plates there shall be used agar-agar media containing 1.5 per cent agar and giving a reaction of 1.0 to phenolphthalein.¹

66. Samples of milk for plating shall be diluted in the proportion of 1 part of milk to 99 parts of sterile water; shake 25 times and plate 1 c. c. of the dilution.¹

67. *Determination of taste and odor of milk.* After the plates have been prepared and placed in the incubator, the taste and odor of the milk shall be determined after warming the milk to 100° F.²

68. *Counts.* The total number of colonies on each plate should be counted, and the results expressed in multiples of the dilution factor. Colonies too small to be seen with the naked eye or with slight magnification shall not be considered in the count.

69. *Records of bacteriologic tests.* The results of all bacterial tests shall be kept on file by the secretary of each commission, copies of which should be made available annually for the use of the American Association of Medical Milk Commissions.

CHEMICAL STANDARDS AND METHODS

The methods that must be followed in carrying out the chemical investigations essential to the protection of certified milk are so complicated that in order to keep the fees of the chemist at a reasonable figure, there must be eliminated from the examination those procedures which, whilst they might be helpful and interesting, are in no sense necessary.

For this reason the determination of the water, the total solids, and the milk sugar is not required as a part of the routine examination.

70. The chemical analyses shall be made by a competent chemist designated by the medical milk commission.

71. *Method of obtaining samples.* The samples to be examined by the chemist shall have been examined previously by the bacteriologist designated by the medical milk commission as to temperature, odor, taste, and bacterial content.

72. *Fat standards.* The fat standard for certified milk shall be 4 per cent, with a permissible range of variation of from 3.5 to 4.5 per cent.

¹ Directions for laboratory work, included in the original report, are here omitted.

² Should it be deemed desirable and necessary to conduct tests for sediment, the presence of special bacteria, or the number of leucocytes, the methods adopted by the committee of the American Public Health Association should be followed.

73. The fat standard for certified cream shall be not less than 18 per cent.

74. If it is desired to sell higher fat-percentage milks or creams as certified milks or creams, the range of variation for such milks shall be 0.5 per cent on either side of the advertised percentage and the range of variations for such creams shall be 2 per cent on either side of the advertised percentage.

75. The fat content of certified milks and creams shall be determined at least once each month.

76. The methods recommended for this purpose are the Babcock,¹ the Leffmann-Beam,¹ and the Gerber.¹

77. Before condemning samples of milk which have fallen outside the limits allowed, the chemist shall have determined, by control ether extractions, that his apparatus and his technique are reliable.

78. *Protein standard.* The protein standard for certified milk shall be 3.50 per cent, with a permissible range of variation of from 3 to 4 per cent.

79. The protein standard for certified cream shall correspond to the protein standard for certified milk.

80. The protein content shall be determined only when any special consideration seems to the medical milk commission to make it desirable.

81. It shall be determined by the Kjeldahl method, using the Gunning or some other reliable modification, and employing the factor 6.25 in reckoning the protein from the nitrogen.

82. *Coloring matter and preservatives.* All certified milks and creams shall be free from adulteration, and coloring matter and preservatives shall not be added thereto.

83. Tests for the detection of added coloring matter shall be applied whenever the color of the milk or cream is such as to arouse suspicion.

84. Tests for the detection of formaldehyde, borax, and boracic acid shall be applied at least once each month. Occasionally application of tests for the detection of salicylic acid, benzoic acid, and the benzoates is also recommended.

85. *Detection of heated milk.* Certified milk or cream shall not be subjected to heat unless specially directed by the commission to meet emergencies.

86. Tests to determine whether such milks and creams have been subjected to heat shall be applied at least once each month.

87. *Specific gravity.* The specific gravity of certified milk shall range from 1.029 to 1.034.

88. The specific gravity shall be determined at least each month.

¹ Directions for laboratory work, included in the original report, are here omitted.

METHODS AND REGULATIONS FOR THE MEDICAL EXAMINATION OF
EMPLOYEES. THEIR HEALTH AND PERSONAL HYGIENE

89. A medical officer, known as the attending dairy physician, shall be selected by the commission, who should reside near the dairy producing certified milk. He shall be a physician in good standing and authorized by law to practice medicine; he shall be responsible to the commission and subject to its direction. In case more than one dairy is under the control of the commission and they are in different localities, a separate physician should be designated for employment for the supervision of each dairy.

90. Before any person shall come on the premises to live and remain as an employee, such person, before being engaged in milking or the handling of milk, shall be subjected to a complete physical examination by the attending physician. No person shall be employed who has not been vaccinated recently or who upon examination is found to have a sore throat, or to be suffering from any form of tuberculosis, venereal disease, conjunctivitis, diarrhea, dysentery, or who has recently had typhoid fever or is proved to be a typhoid carrier, or who has any inflammatory disease of the respiratory tract, or any suppurative process or infectious skin eruption, or any disease of an infectious or contagious nature, or who has recently been associated with children sick with contagious disease.

91. In addition to ordinary habits of personal cleanliness all milkers shall have well-trimmed hair, wear close-fitting caps, and have clean-shaven faces.

92. When the milkers live upon the premises their dormitories shall be constructed and operated according to plans approved by the commission. A separate bed shall be provided for each milker and each bed shall be kept supplied with clean bedclothes. Proper bathing facilities shall be provided for all employees on the dairy premises, preferably a shower bath, and frequent bathing shall be enjoined.

93. In case the employees live on the dairy premises a suitable building shall be provided to be used for the isolation and quarantine of persons under suspicion of having a contagious disease.

The following plan of construction is recommended:

The quarantine building and hospital should be one story high and contain at least two rooms, each with a capacity of about 6,000 cubic feet and containing not more than three beds each, the rooms to be separated by a closed partition. The doors opening into the rooms should be on opposite sides of the building and provided with locks. The windows should be barred and the sash should be at least 5 feet from the ground and constructed for proper ventilation. The walls should be of a material which will allow proper disinfection. The floor should be of painted or washable wood, preferably of concrete, and so constructed that the floor may be flushed and properly dis-

infected. Proper heating, lighting, and ventilating facilities should be provided.

94. In the event of any illness of a suspicious nature the attending physician shall immediately quarantine the suspect, notify the health authorities and the secretary of the commission, and examine each member of the dairy force, and in every inflammatory affection of the nose or throat occurring among the employees of the dairy, in addition to carrying out the above-mentioned program, the attending physician shall take a culture and have it examined at once by a competent bacteriologist approved by the commission. Pending such examination, the affected employee or employees shall be quarantined.

95. It shall be the duty of the secretary, on receiving notice of any suspicious or contagious disease at the dairy, at once to notify the committee having in charge the medical supervision of employees of the dairy farm upon which such disease has developed. On receipt of the notice this committee shall assume charge of the matter, and shall have power to act for the commission as its judgment dictates. As soon as possible thereafter, the committee shall notify the commission, through its secretary, that a special meeting may be called for ultimate consideration and action.

96. When a case of contagious disease is found among the employees of a dairy producing certified milk under the control of a medical milk commission, such employee shall be at once quarantined and as soon as possible removed from the plant, and the premises fumigated.

When a case of contagion is found on a certified dairy it is advised that a printed notice of the facts shall be sent to every householder using the milk, giving in detail the precautions taken by the dairyman under the direction of the commission, and it is further advised that all milk produced at such dairy shall be heated at 145° F. for 40 minutes, or 155° F. for 30 minutes, or 167° F. for 20 minutes, and immediately cooled to 50° F. These facts should also be part of the notice, and such heating of the milk should be continued during the accepted period of incubation for such contagious disease.

The following method of fumigation is recommended :

After all windows and doors are closed and the cracks sealed by strips of paper applied with flour paste, and the various articles in the room so hung or placed as to be exposed on all sides, preparations should be made to generate formaldehyde gas by the use of 20 ounces of formaldehyde and 10 ounces of permanganate of potash for every 1,000 cubic feet of space to be disinfected.

For mixing the formaldehyde and potassium permanganate a large galvanized-iron pail or cylinder holding at least 20 quarts and having a flared top should be used for mixing therein 20 ounces of formaldehyde and 10 ounces of permanganate. A cylinder at least 5 feet high is suggested. The containers should be placed about in the rooms and the necessary quantity of

permanganate weighed and placed in them. The formaldehyde solution for each pail should then be measured into a wide-mouthed cup and placed by the pail in which it is to be used.

Although the reaction takes place quickly, by making preparations as advised all of the pails can be "set off" promptly by one person, since there is nothing to do but pour the formaldehyde solution over the permanganate. The rooms should be kept closed for four hours. As there is a slight danger of fire, the reaction should be watched through a window or the pails placed on a noninflammable surface.

97. Following a weekly medical inspection of the employees, a monthly report shall be submitted to the secretary of the medical milk commission, on the same recurring date by the examining visiting physician.

The following schedule, filled out in writing and signed by himself, is recommended as a suitable form for the attending physician's report.

This is to certify that, on the dates below indicated, official visits were made to the — dairy, owned and conducted by — of — (indicating town and State), where careful inspections of the dairy employees were made.

- (a) Number and dates of visits since last report. —.
- (b) Number of men employed on the plant. —.
- (c) Has a recent epidemic of contagion occurred near the dairy, and what was its nature and extent? —.
- (d) Have any cases of contagious or infectious disease occurred among the men since the last report? —.
- (e) Disposition of such cases. —.
- (f) What individual sickness has occurred among the men since the last report? —.
- (g) Disposition of such cases. —.
- (h) Number of employees now quarantined for sickness. —.
- (i) Describe the personal hygiene of the men employed for milking when prepared for and during the process of milking. —.
- (j) What facilities are provided for sickness in employees? —.
- (k) General hygienic condition of the dormitories or houses of the employees. —.
- (l) Suggestions for improvement. —.
- (m) What is the hygienic condition of the employees and their surroundings? —.
- (n) How many employees were examined at each of the foregoing visits? —.
- (o) Remarks.

Date, —.

_____,
Attending Physician.

APPENDIX D

FEDERAL MEAT INSPECTION

THE MEAT-INSPECTION LAW

[Extract from an act of Congress entitled "An act making appropriations for the Department of Agriculture for the fiscal year ending June thirtieth, nineteen hundred and seven," approved June 30, 1906 (34 Stat., 674).]

That for the purpose of preventing the use in interstate or foreign commerce, as hereinafter provided, of meat and meat food products which are unsound, unhealthful, unwholesome, or otherwise unfit for human food, the Secretary of Agriculture, at his discretion, may cause to be made, by inspectors appointed for that purpose, an examination and inspection of all cattle, sheep, swine, and goats before they shall be allowed to enter into any slaughtering, packing, meat-canning, rendering, or similar establishment, in which they are to be slaughtered and the meat and meat food products thereof are to be used in interstate or foreign commerce; and all cattle, swine, sheep, and goats found on such inspection to show symptoms of disease shall be set apart and slaughtered separately from all other cattle, sheep, swine, or goats, and when so slaughtered the carcasses of said cattle, sheep, swine, or goats shall be subject to a careful examination and inspection, all as provided by the rules and regulations to be prescribed by the Secretary of Agriculture as herein provided for.

That for the purposes hereinbefore set forth the Secretary of Agriculture shall cause to be made by inspectors appointed for that purpose, as hereinafter provided, a post-mortem examination and inspection of the carcasses and parts thereof of all cattle, sheep, swine, and goats to be prepared for human consumption at any slaughtering, meat-canning, salting, packing, rendering, or similar establishment in any State, Territory, or the District of Columbia for transportation or sale as articles of interstate or foreign commerce; and the carcasses and parts thereof of all such animals found to be

sound, healthful, wholesome, and fit for human food shall be marked, stamped, tagged, or labeled as "Inspected and Passed;" and said inspectors shall label, mark, stamp, or tag as "Inspected and Condemned," all carcasses and parts thereof of animals found to be unsound, unhealthful, unwholesome, or otherwise unfit for human food; and all carcasses and parts thereof thus inspected and condemned shall be destroyed for food purposes by the said establishment in the presence of an inspector, and the Secretary of Agriculture may remove inspectors from any such establishment which fails to so destroy any such condemned carcass or part thereof, and said inspectors, after said first inspection shall, when they deem it necessary, reinspect said carcasses or parts thereof to determine whether since the first inspection the same have become unsound, unhealthful, unwholesome, or in any way unfit for human food, and if any carcass or any part thereof shall, upon examination and inspection subsequent to the first examination and inspection, be found to be unsound, unhealthful, unwholesome, or otherwise unfit for human food, it shall be destroyed for food purposes by the said establishment in the presence of an inspector, and the Secretary of Agriculture may remove inspectors from any establishment which fails to so destroy any such condemned carcass or part thereof.

The foregoing provisions shall apply to all carcasses or parts of carcasses of cattle, sheep, swine, and goats, or the meat or meat products thereof which may be brought into any slaughtering, meat-canning, salting, packing, rendering, or similar establishment, and such examination and inspection shall be had before the said carcasses or parts thereof shall be allowed to enter into any department wherein the same are to be treated and prepared for meat food products; and the foregoing provisions shall also apply to all such products which, after having been issued from any slaughtering, meat canning, salting, packing, rendering, or similar establishment, shall be returned to the same or to any similar establishment where such inspection is maintained.

That for the purposes hereinbefore set forth the Secretary of Agriculture shall cause to be made by inspectors appointed for that purpose an examination and inspection of all meat food products prepared for interstate or foreign commerce in any slaughtering, meat-canning, salting, packing, rendering, or similar establishment, and for the purposes of any examination and inspection said inspectors shall have access at all times, by day or night, whether the establishment be operated or not, to every part of said establishment; and said inspectors shall mark, stamp, tag, or label as "Inspected and Passed" all such products found to be sound, healthful, and wholesome, and which contain no dyes, chemicals, preservatives, or ingredients which render such meat or meat food products unsound, unhealthful, unwholesome, or

unfit for human food; and said inspectors shall label, mark, stamp, or tag as "Inspected and Condemned" all such products found unsound, unhealthful, and unwholesome, or which contain dyes, chemicals, preservatives, or ingredients which render such meat or meat food products unsound, unhealthful, unwholesome, or unfit for human food, and all such condemned meat food products shall be destroyed for food purposes, as hereinbefore provided, and the Secretary of Agriculture may remove inspectors from any establishment which fails to so destroy such condemned meat food products: *Provided*, That, subject to the rules and regulations of the Secretary of Agriculture, the provisions hereof in regard to preservatives shall not apply to meat food products for export to any foreign country and which are prepared or packed according to the specifications or directions of the foreign purchaser, when no substance is used in the preparation or packing thereof in conflict with the laws of the foreign country to which said article is to be exported; but if said article shall be in fact sold or offered for sale for domestic use or consumption, then this proviso shall not exempt said article from the operation of all the other provisions of this act.

That when any meat or meat food product prepared for interstate or foreign commerce which has been inspected as hereinbefore provided and marked "Inspected and Passed" shall be placed or packed in any can, pot, tin, canvas, or other receptacle or covering in any establishment where inspection under the provisions of this act is maintained, the person, firm, or corporation preparing said product shall cause a label to be attached to said can, pot, tin, canvas, or other receptacle or covering, under the supervision of an inspector, which label shall state that the contents thereof have been "Inspected and Passed" under the provisions of this act; and no inspection and examination of meat or meat food products deposited or inclosed in cans, tins, pots, canvas, or other receptacle or covering in any establishment where inspection under the provisions of this act is maintained shall be deemed to be complete until such meat or meat food products have been sealed or inclosed in said can, tin, pot, canvas, or other receptacle or covering under the supervision of an inspector, and no such meat or meat food products shall be sold or offered for sale by any person, firm, or corporation in interstate or foreign commerce under any false or deceptive name; but established trade name or names which are usual to such products and which are not false and deceptive and which shall be approved by the Secretary of Agriculture are permitted.

The Secretary of Agriculture shall cause to be made, by experts in sanitation or by other competent inspectors, such inspection of all slaughtering, meat-canning, salting, packing, rendering, or similar establishments in which cattle, sheep, swine, and goats are slaughtered and the meat and meat food

products thereof are prepared for interstate or foreign commerce as may be necessary to inform himself concerning the sanitary conditions of the same, and to prescribe the rules and regulations of sanitation under which such establishments shall be maintained; and where the sanitary conditions of any such establishment are such that the meat or meat food products are rendered unclean, unsound, unhealthful, unwholesome, or otherwise unfit for human food, he shall refuse to allow said meat or meat food products to be labeled, marked, stamped, or tagged as "Inspected and Passed."

That the Secretary of Agriculture shall cause an examination and inspection of all cattle, sheep, swine, and goats, and the food products thereof, slaughtered and prepared in the establishments hereinbefore described for the purposes of interstate or foreign commerce to be made during the nighttime as well as during the daytime when the slaughtering of said cattle, sheep, swine, and goats, or the preparation of said food products is conducted during the night time.

That on and after October first, nineteen hundred and six, no person, firm, or corporation shall transport or offer for transportation, and no carrier of interstate or foreign commerce shall transport or receive for transportation from one State or Territory or the District of Columbia to any other State or Territory of the District of Columbia, or to any place under the jurisdiction of the United States, or to any foreign country, any carcasses or parts thereof, meat, or meat food products thereof which have not been inspected, examined, and marked as "Inspected and Passed," in accordance with the terms of this act and with the rules and regulations prescribed by the Secretary of Agriculture: *Provided*, That all meat and meat food products on hand on October first, nineteen hundred and six, at establishments where inspection has not been maintained, or which have been inspected under existing law, shall be examined and labeled under such rules and regulations as the Secretary of Agriculture shall prescribe, and then shall be allowed to be sold in interstate or foreign commerce.

That no person, firm, or corporation, or officer, agent, or employee thereof shall forge, counterfeit, simulate, or falsely represent, or shall without proper authority use, fail to use, or detach, or shall knowingly or wrongfully alter, deface, or destroy, or fail to deface or destroy, any of the marks, stamps, tags, labels, or other identification devices provided for in this act, or in and as directed by the rules and regulations prescribed hereunder by the Secretary of Agriculture, on any carcasses, parts of carcasses, or the food product, or containers thereof, subject to the provisions of this act, or any certificate in relation thereto, authorized or required by this act or by the said rules and regulations of the Secretary of Agriculture.

That the Secretary of Agriculture shall cause to be made a careful inspection of all cattle, sheep, swine, and goats intended and offered for export to foreign countries at such times and places, and in such manner as he may deem proper, to ascertain whether such cattle, sheep, swine, and goats are free from disease.

And for this purpose he may appoint inspectors who shall be authorized to give an official certificate clearly stating the condition in which such cattle, sheep, swine, and goats are found.

And no clearance shall be given to any vessel having on board cattle, sheep, swine, or goats for export to a foreign country until the owner or shipper of such cattle, sheep, swine, or goats has a certificate from the inspector herein authorized to be appointed, stating that the said cattle, sheep, swine, or goats are sound and healthy, or unless the Secretary of Agriculture shall have waived the requirement of such certificate for export to the particular country to which such cattle, sheep, swine, or goats are to be exported.

That the Secretary of Agriculture shall also cause to be made a careful inspection of the carcasses and parts thereof of all cattle, sheep, swine, and goats, the meat of which, fresh, salted, canned, corned, packed, cured, or otherwise prepared, is intended and offered for export to any foreign country, at such times and places and in such manner as he may deem proper.

And for this purpose he may appoint inspectors who shall be authorized to give an official certificate stating the condition in which said cattle, sheep, swine, or goats, and the meat thereof, are found.

And no clearance shall be given to any vessel having on board any fresh, salted, canned, corned, or packed beef, mutton, pork, or goat meat, being the meat of animals killed after the passage of this act, or except as hereinbefore provided for export to and sale in a foreign country from any port in the United States, until the owner or shipper thereof shall obtain from an inspector appointed under the provisions of this act a certificate that the said cattle, sheep, swine, and goats were sound and healthy at the time of inspection, and that their meat is sound and wholesome, unless the Secretary of Agriculture shall have waived the requirements of such certificate for the country to which said cattle, sheep, swine, and goats or meats are to be exported.

That the inspectors provided for herein shall be authorized to give official certificates of the sound and wholesome condition of the cattle, sheep, swine, and goats, their carcasses and products as herein described, and one copy of every certificate granted under the provisions of this act shall be filed in the Department of Agriculture, another copy shall be delivered to the owner or shipper, and when the cattle, sheep, swine, and goats or their carcasses and products are sent abroad, a third copy shall be delivered to the chief officer of the vessel on which the shipment shall be made.

That no person, firm, or corporation engaged in the interstate commerce of meat or meat food products shall transport or offer for transportation, sell or offer to sell any such meat or meat food products in any State or Territory or in the District of Columbia or any place under the jurisdiction of the United States, other than in the State or Territory or in the District of Columbia or any place under the jurisdiction of the United States in which the slaughtering, packing, canning, rendering, or other similar establishment owned, leased, operated by said firm, person, or corporation is located unless and until said person, firm, or corporation shall have complied with all of the provisions of this act.

That any person, firm, or corporation, or any officer or agent of any such person, firm, or corporation, who shall violate any of the provisions of this act shall be deemed guilty of a misdemeanor, and shall be punished on conviction thereof by a fine of not exceeding ten thousand dollars or imprisonment for a period not more than two years or by both such fine and imprisonment, in the discretion of the court.

That the Secretary of Agriculture shall appoint from time to time inspectors to make examination and inspection of all cattle, sheep, swine, and goats, the inspection of which is hereby provided for, and of all carcasses and parts thereof, and of all meats and meat food products thereof, and of the sanitary conditions of all establishments in which such meat and meat food products hereinbefore described are prepared; and said inspectors shall refuse to stamp, mark, tag, or label any carcass or any part thereof, or meat food product therefrom, prepared in any establishment hereinbefore mentioned, until the same shall have actually been inspected and found to be sound, healthful, wholesome, and fit for human food, and to contain no dyes, chemicals, preservatives, or ingredients which render such meat food product unsound, unhealthful, unwholesome, or unfit for human food; and to have been prepared under proper sanitary conditions, hereinbefore provided for; and shall perform such other duties as are provided by this act and by the rules and regulations to be prescribed by said Secretary of Agriculture; and said Secretary of Agriculture shall, from time to time, make such rules and regulations as are necessary for the efficient execution of the provisions of this act, and all inspections and examinations made under this act shall be such and made in such manner as described in the rules and regulations prescribed by said Secretary of Agriculture not inconsistent with the provisions of this act.

That any person, firm, or corporation, or any agent or employee of any person, firm, or corporation, who shall give, pay, or offer, directly or indirectly, to any inspector, deputy inspector, chief inspector, or any other officer or employee of the United States authorized to perform any of the duties pre-

scribed by this act or by the rules and regulations of the Secretary of Agriculture any money or other thing of value, with intent to influence said inspector, deputy inspector, chief inspector, or other officer or employee of the United States in the discharge of any duty herein provided for, shall be deemed guilty of a felony and, upon conviction thereof, shall be punished by a fine not less than five thousand dollars nor more than ten thousand dollars and by imprisonment not less than one year nor more than three years; and any inspector, deputy inspector, chief inspector, or other officer or employee of the United States authorized to perform any of the duties prescribed by this act who shall accept any money, gift, or other thing of value from any person, firm, or corporation, or officers, agents, or employees thereof, given with intent to influence his official action, or who shall receive or accept from any person, firm, or corporation engaged in interstate or foreign commerce any gift, money, or other thing of value given with any purpose or intent whatsoever, shall be deemed guilty of a felony and shall, upon conviction thereof, be summarily discharged from office and shall be punished by a fine not less than one thousand dollars nor more than ten thousand dollars and by imprisonment not less than one year nor more than three years.

That the provisions of this act requiring inspection to be made by the Secretary of Agriculture shall not apply to animals slaughtered by any farmer on the farm and sold and transported as interstate or foreign commerce, nor to retail butchers and retail dealers in meat and meat food products, supplying their customers: *Provided*, That if any person shall sell or offer for sale or transportation for interstate or foreign commerce any meat or meat food products which are diseased, unsound, unhealthful, unwholesome, or otherwise unfit for human food, knowing that such meat food products are intended for human consumption, he shall be guilty of a misdemeanor, and on conviction thereof shall be punished by a fine not exceeding one thousand dollars or by imprisonment for a period of not exceeding one year, or by both such fine and imprisonment: *Provided also*, That the Secretary of Agriculture is authorized to maintain the inspection in this act provided for at any slaughtering, meat canning, salting, packing, rendering, or similar establishment notwithstanding this exception, and that the persons operating the same may be retail butchers and retail dealers or farmers; and where the Secretary of Agriculture shall establish such inspection then the provisions of this act shall apply notwithstanding this exception.

That there is permanently appropriated, out of any money in the Treasury not otherwise appropriated, the sum of three million dollars, for the expenses of the inspection of cattle, sheep, swine, and goats and the meat and meat food products thereof which enter into interstate or foreign commerce and for all expenses necessary to carry into effect the provisions of this act

relating to meat inspection, including rent and the employment of labor in Washington and elsewhere, for each year. And the Secretary of Agriculture shall, in his annual estimates made to Congress, submit a statement in detail, showing the number of persons employed in such inspections and the salary or per diem paid to each, together with the contingent expenses of such inspectors and where they have been and are employed.

EXTRACTS FROM MEAT INSPECTION REGULATIONS
UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ANIMAL INDUSTRY

Order 211

[Effective November 1, 1914.]

* * * * * * *

Regulation 8. Sanitation

SECTION 1. Prior to the inauguration of inspection, an examination of the establishment and premises shall be made by a bureau¹ employee and the requirements for sanitation and the necessary facilities for inspection specified.

SECTION 2. Triplicate copies of plans, properly drawn to scale, and of specifications, including plumbing and drainage, for remodeling plants of official establishments and for new structures, shall be submitted to the chief of bureau in advance of construction.

SECTION 3. *Paragraph 1.* Official establishments, establishments at which market inspection is conducted, and premises on or in which any meat or product is prepared or handled by or for persons to whom certificates of exemption have been issued, shall be maintained in sanitary condition, and to this end the requirements of paragraphs 2 to 8, inclusive, of this section shall be complied with.

¹ Throughout the regulations the word bureau is used to designate the Bureau of Animal Industry.

Paragraph 2. There shall be abundant light, both natural and artificial, and sufficient ventilation for all rooms and compartments, to insure sanitary condition.

Paragraph 3. There shall be an efficient drainage and plumbing system for the establishment and premises, and all drains and gutters shall be properly installed with approved traps and vents.

Paragraph 4. The water supply shall be ample, clean, and potable, with adequate facilities for its distribution in the plant. Every establishment shall make known, and whenever required shall afford opportunity for inspection of, the source of its water supply and the location and character of its reservoir and storage tanks.

Paragraph 5. The floors, walls, ceilings, partitions, posts, doors, and other parts of all structures shall be of such materials, construction, and finish as will make them susceptible of being readily and thoroughly cleaned. The floors shall be kept water-tight. The rooms and compartments used for edible products shall be separate and distinct from those used for inedible products.

Paragraph 6. The rooms and compartments in which any meat or product is prepared or handled shall be free from odors from dressing and toilet rooms, catch basins, hide cellars, casing rooms, inedible tank and fertilizer rooms, and stables.

Paragraph 7. Every practicable precaution shall be taken to keep establishments free of flies, rats, mice, and other vermin. The use of rat poisons is prohibited in rooms or compartments where any unpacked meat or product is stored or handled; but their use is not forbidden in hide cellars, inedible compartments, outbuildings, or similar places, or in storerooms containing canned or tierced products. So-called rat viruses shall not be used in any part of an establishment or the premises thereof.

Paragraph 8. Dogs shall not be admitted into official establishments except, upon permission of the inspector in charge, for

the purpose of destroying rats. Dogs which are admitted shall be kept free from tapeworm infestation. Such examinations shall be made to determine freedom from infestation as the chief of bureau may prescribe. Contamination by the excreta of these animals shall not be permitted, nor shall the dogs be allowed to eat the raw viscera of cattle, sheep, swine, or goats.

SECTION 4. Adequate sanitary facilities and accommodations shall be furnished by every official establishment. Of these the following are specifically required:

(a) Dressing rooms, toilet rooms, and urinals, sufficient in number, ample in size, conveniently located, properly ventilated, and meeting all requirements as to sanitary construction and equipment. These shall be separate from the rooms and compartments in which meat and products are prepared, stored, or handled. Where both sexes are employed, separate facilities shall be provided.

(b) Modern lavatory accommodations, including running hot and cold water, soap, towels, etc. These shall be placed in or near toilet and urinal rooms and also at such other places in the establishment as may be essential to assure cleanliness of all persons handling any meat or product.

(c) Properly located facilities for disinfecting and cleansing utensils and hands of all persons handling any meat or product.

(d) Cuspidors of such shape as not readily to be upset and of such material as to be readily disinfected. They shall be sufficient in number and accessibly placed in all rooms and places designated by the inspector in charge, and all persons who expectorate shall be required to use them.

SECTION 5. Equipment and utensils used for preparing, processing, and otherwise handling any meat or product shall be of such materials and construction as will make them susceptible of being readily and thoroughly cleaned and such as will insure strict cleanliness in the preparation and handling of all meat and products. Trucks and receptacles used for inedible prod-

ucts shall bear some conspicuous and distinctive mark and shall not be used for handling edible products.

SECTION 6. Rooms, compartments, places, equipment, and utensils used for preparing, storing, or otherwise handling any meat or product, and all other parts of the establishment, shall be kept clean and sanitary.

SECTION 7. *Paragraph 1.* Operations and procedures involving the preparation, storing, or handling of any meat or product shall be strictly in accord with cleanly and sanitary methods.

Paragraph 2. Rooms and compartments in which inspections are made and those in which animals are slaughtered or any meat or product is processed or prepared shall be kept sufficiently free of steam and vapors to enable bureau employees to make inspections and to insure cleanly operations. The walls and ceilings of rooms and compartments under refrigeration shall be kept reasonably free from moisture.

Paragraph 3. Butchers and others who dress or handle diseased carcasses or parts shall, before handling or dressing other carcasses or parts, cleanse their hands of grease, immerse them in a prescribed disinfectant, and rinse them in clean water. Implements used in dressing diseased carcasses shall be thoroughly cleansed in boiling water or in a prescribed disinfectant, followed by rinsing in clean water. The employees of the establishment who handle any meat or product shall keep their hands clean, and in all cases after visiting the toilet rooms or urinals shall wash their hands before handling any meat or product or implements used in the preparation of the same.

Paragraph 4. Aprons, frocks, and other outer clothing worn by persons who handle any meat or product shall be of material that is readily cleansed, and only clean garments shall be worn. Knife scabbards shall be kept clean.

Paragraph 5. Such practices as spitting on whetstones, placing skewers or knives in the mouth, inflating lungs or cas-

ings, or testing with air from the mouth such receptacles as tierces, kegs, casks, and the like, containing or intended as containers of any meat or product, are prohibited. Only mechanical means may be used for testing.

SECTION 8. The wagons and cars in which any meat or product is transported shall be kept in a clean and sanitary condition. Wagons used in transferring loose meat and products between official establishments shall be closed or so covered that the contents shall be kept clean.

SECTION 9. *Paragraph 1.* Second-hand tubs, barrels, and boxes intended for use as containers of any meat or product shall be inspected when received at the establishment and before they are cleaned. Those showing evidence of misuse rendering them unfit to serve as containers for food products shall be rejected. The use of those showing no evidence of previous misuse may be allowed after they have been thoroughly and properly cleaned. Steaming, after thorough scrubbing and rinsing, is essential to cleaning tubs and barrels.

Paragraph 2. Interiors of tank cars about to be used for the transportation of any meat food product shall be carefully inspected for cleanliness even though the last previous content was edible. Lye and soda solutions used in cleaning must be thoroughly removed by rinsing with clean water. In their examinations bureau employees shall enter the tank with a light and examine all parts of the interior.

SECTION 10. The outer premises of every official establishment, embracing docks and areas where cars and wagons are loaded, and the driveways, approaches, yards, pens, and alleys, shall be properly drained and kept in clean and orderly condition. All catch basins on the premises shall be of such construction and location and be given such attention as will insure their being kept in acceptable condition as regards odors and cleanliness. The accumulation on the premises of establishments of any material in which flies may breed, such as hog hair.

bones, paunch contents, or manure, is forbidden. No nuisance shall be allowed in any establishment or on its premises.

SECTION 11. No establishment shall employ in any department where any meat or product is handled or prepared any person affected with tuberculosis or other communicable disease.

SECTION 12. When necessary, bureau employees shall attach a "U. S. rejected" tag to any equipment or utensil which is insanitary, or the use of which would be in violation of these regulations. No equipment or utensil so tagged shall again be used until made sanitary. Such tag so placed shall not be removed by any one other than a bureau employee.

Regulation 9. Ante-mortem Inspection

SECTION 1. *Paragraph 1.* An ante-mortem examination and inspection shall be made of all cattle, sheep, swine, and goats about to be slaughtered in an official establishment before their slaughter shall be allowed.

* * * * *

SECTION 2. *Paragraph 1.* All animals plainly showing on ante-mortem inspection any disease or condition that under these regulations would cause condemnation of their carcasses on post-mortem inspection shall be marked "U. S. condemned" and disposed of in accordance with section 8 of this regulation.

* * * * *

SECTION 3. All animals required by these regulations to be treated as suspects, or to be marked as suspects, or to be marked so as to retain their identity as suspects, shall be marked by or under the supervision of a bureau employee, "U. S. suspect," or with such other distinctive mark or marks to indicate that they are suspects as the chief of bureau may adopt. No such mark shall be removed except by a bureau employee.

* * * * *

SECTION 8. Animals marked "U. S. condemned" shall be killed by the establishment, if not already dead, and shall not be taken into an establishment to be slaughtered or dressed, nor shall they be conveyed into any department of the establishment used for edible products, but they shall be disposed of and tanked in the manner provided for condemned carcasses. . . .

* * * * *

Regulation 10. Post-mortem Inspection

SECTION 1. A careful post-mortem examination and inspection shall be made of the carcasses and parts thereof of all cattle, sheep, swine, and goats slaughtered at official establishments.

* * * * *

SECTION 3. *Paragraph 1.* Each carcass, including all parts and detached organs thereof, in which any lesion of disease or other condition is found that might render the meat or any organ unfit for food purposes, and which for that reason would require a subsequent inspection, shall be retained by the bureau employee at the time of inspection and taken to the place designated for final inspection.

* * * * *

SECTION 4. Each carcass or part which is found on final inspection to be unsound, unhealthful, unwholesome, or otherwise unfit for human food shall be conspicuously marked on the surface tissues thereof by a bureau employee at the time of inspection "U. S. inspected and condemned." Condemned detached organs and parts of such character that they cannot be so marked shall be immediately placed in trucks or receptacles which shall be kept plainly marked "U. S. inspected and condemned" in letters not less than 2 inches high. All condemned carcasses, parts, and organs shall remain in the custody of a bureau employee and shall be tanked as required in these

regulations at or before the close of the day on which they are condemned, or be locked in the "U. S. condemned" room or compartment. Condemned articles shall not be allowed to accumulate unnecessarily in the condemned room or compartment.

SECTION 5. *Paragraph 1.* Carcasses and parts passed for sterilization shall be conspicuously marked on the surface tissues thereof by a bureau employee at the time of inspection "Passed for sterilization." All such carcasses and parts shall be sterilized in accordance with regulation 15 and until so sterilized shall remain in the custody of a bureau employee.

Paragraph 2. In all cases where carcasses showing localized lesions of disease are passed for food or for sterilization the diseased parts shall be removed before the "U. S. retained" tag is taken from the carcass, and such parts shall be condemned.

* * * * *

Regulation 15. Rendering Carcasses and Parts into Lard and Tallow, and Other Sterilization

SECTION 1. Carcasses and parts passed for sterilization may be rendered into lard or tallow provided that such rendering is done in the following manner: The lower opening of the tank shall first be securely sealed by a bureau employee, then the carcasses or parts shall be placed in the tank in his presence, after which the upper opening shall be securely sealed by such employee, who shall then see that a sufficient force of steam is turned into the tank. Such carcasses and parts shall be cooked at a temperature not lower than 220° F. for a time sufficient to render them effectually into lard or tallow.

SECTION 2. Establishments not equipped with steaming tanks for rendering carcasses and parts into lard or tallow as provided in section 1 of this regulation may render such carcasses or parts in open kettles under the direct supervision of a bureau employee. Such rendering shall be done at a temper-

ature and for a time sufficient to render the carcasses and parts effectually into lard or tallow, and shall be done only during regular hours of work.

SECTION 3. *Paragraph 1.* Carcasses and parts passed for sterilization and which are not rendered into lard or tallow may be utilized for food purposes provided they are first sterilized by methods, and handled and marked in a manner approved by the chief of bureau.

Paragraph 2. Any carcasses or parts prepared in compliance with paragraph 1 of this section may be canned if the container be plainly and conspicuously marked so as to show that the product is second grade, class, or quality and has been sterilized.

* * * * *

APPENDIX E

TABLE OF 100-CALORIE PORTIONS

EXPLANATION OF TABLE. — The first column of figures in the table gives the number of 100-Calorie portions in one pound of the food as purchased. The next four columns show the weight of food which yields 100 Calories, *i.e.* the weight of the 100-Calorie portion, both in ounces and in grams, and both for the material as purchased and for the edible portion. Next follow columns showing the amounts of protein (in Calories and in grams) and the amounts of calcium, calculated as CaO, phosphorus, calculated as P_2O_5 , and iron, calculated as Fe, in the 100-Calorie portion. Finally there is given the balance of acid-forming and base-forming elements contained in the 100-Calorie portion, expressed as excess of acid or of base and stated in terms of the units explained on pages 352 and 353.

It is estimated that meats contain 0.00075 gram of CaO, 0.023 gram P_2O_5 , 0.00015 gram Fe, and yield 0.5 unit of excess acid for every gram of protein; and that fish contain 0.0015 gram CaO, 0.025 gram P_2O_5 , 0.00004 gram Fe, and yield 0.5 unit of excess acid for every gram of protein. These estimates have been used in calculating the figures given for the different cuts of meat and for the different kinds of fish.

FOOD MATERIAL	POR- TIONS IN ONE POUND AS PUR- CHASED	WEIGHT IN OUNCES		WEIGHT IN GRAMS		AMOUNT OF			EXCESS OF	
		As pur- chased	Edible portion	As pur- chased	Edible portion	Protein		CaO Gram	P ₂ O ₅ Gram	Fe Gram
						Calories	Grams			
Almonds	16.1	.99	.54	28	15	12.9	3.22	.046	.132	.0003
Apples, fresh	2.1	7.49	5.61	212	159	2.6	.65	.022	.05	.0005
dried	13.2	1.21	1.21	34	34	2.6	.65	.022	.05	.0005
Apricots, fresh	2.4	6.48	6.08	184	172	7.6	1.90	.031	.10	.0005
dried	12.6	1.27	1.27	36	36	7.6	1.90	.031	.10	.0005
Asparagus, fresh	1.	15.89	15.89	450	450	32.4	8.10	.17	.39	.0043
cooked	2.1	7.46	7.46	213	213	17.9	4.47	.001	.04	.0002
Bacon, smoked	23.7	.62	.56	17	16	6.7	1.67	.01	.055	.0006
Bananas	2.9	5.52	3.58	156	101	5.3	1.32	.01	.127	.00036
Barley, pearled	16.2	0.99	0.99	28	28	9.5	2.37	.007	.265	.0016
Beans, baked, canned	5.8	2.75	2.75	78	78	21.5	5.30	.051 ¹	.326	.0020
dried	15.7	1.02	1.02	29	29	26.1	6.52	.063	.219	.00195
lima, canned	3.5	4.59	4.59	130	130	20.8	5.20	.028	.219	.00195
dried	15.9	1.02	1.02	29	29	20.7	5.17	.028	.221	.0020
fresh	2.5	6.40	2.88	182	82	23.2	5.80	.033	.284	.0038
string, canned	0.9	17.10	17.10	488	488	21.5	5.30	.177	.284	.0038
fresh	1.7	9.11	8.50	259	241	22.2	5.55	.177	.37	.0038
kidney, canned	5.4	2.93	2.93	83	83	23.3	5.82	.05	.37	.0038
kidney, dried	12.3	1.02	1.02	29	29	47.3	11.82	.05	.37	.0038

¹ If molasses is used in preparation, CaO would be higher.

Beef, brisket, med. fat	11.3	1.41	1.09	40	31	19.6	4.90	.0004	.113	.00073	2.4
chuck, average	8.	2.05	1.62	58	46	30.7	7.67	.006	.176	.0015	3.8
corned	12.3	1.30	1.18	37	34	20.9	5.22	.004	.120	.00078	2.6
cross ribs, average	12.6	1.27	1.13	36	32	20.4	5.10	.004	.117	.00076	2.5
dried, salted, smoked	7.2	2.11	1.96	60	56	66.6	16.65	.012	.382	.00250	8.3
flank, lean	8.4	1.94	1.91	55	54	44.8	11.20	.008	.258	.00168	5.6
fore quarter, lean	6.5	2.43	1.91	69	54	40.8	10.20	.008	.235	.00153	5.1
fore shank, lean	4.1	3.88	2.47	110	70	61.6	15.40	.011	.354	.00230	7.7
heart	12.9	1.41	1.23	40	35	25.6	6.40	.005	.147	.00096	3.2
hind quarter, lean	7.6	2.12	1.76	60	50	40.0	10.00	.008	.23	.00150	5.
hind shank, lean	2.5	6.31	2.65	179	75	65.7	16.42	.012	.378	.00246	8.2
hind shank, fat	5.5	2.93	1.41	83	40	32.6	8.15	.006	.187	.00122	4.
juice	1.1		14.11		400	78.4	19.60	.015	.451	.00204	9.8
kidney	3.3	4.91	3.17	139	90	50.7	14.92	.011	.343	.00224	7.4
liver	5.4	2.97	2.73	85	78	63.3	15.82	.012	.364	.00237	7.9
loin	7.6	2.09	1.83	60	52	40.7	10.17	.008	.234	.00152	5.8
neck, lean	5.1	3.11	2.19	88	62	53.0	13.25	.010	.305	.0020	6.6
neck, medium fat	7.5	2.14	1.54	61	44	35.1	8.77	.007	.202	.0013	4.3
plate, lean	8.7	1.84	1.52	52	43	27.0	6.75	.005	.155	.0010	3.3
porterhouse steak	10.8	1.48	1.30	42	37	32.3	8.07	.006	.186	.0012	4.0
rib rolls, lean	8.	2.01	2.01	57	57	46.1	11.52	.087	.265	.0017	5.7
ribs, lean	6.5	2.44	1.89	69	54	42.0	10.50	.008	.242	.0016	5.2
ribs, fat	14.8	1.09	.92	31	26	15.6	3.90	.003	.090	.0006	1.9
roast	15.8	1.03	1.03	29	29	27.5	6.87	.052	.016	.0010	3.4
round, lean	6.5	2.45	2.26	70	64	54.5	13.62	.010	.313	.0020	6.8
round, free from visible fat	5.1	3.07	3.07	87	87	80.7	20.18	.015	.464	.0030	10.0
rump, lean	8.	2.01	1.70	57	49	40.4	10.10	.008	.232	.0015	5.0

FOOD MATERIAL	POR- TIONS IN ONE POUND AS PUR- CHASED	WEIGHT IN OUNCES		WEIGHT IN GRAMS		AMOUNT OF			EXCESS OF			
		As pur- chased	Edible portion	As pur- chased	Edible portion	Protein	CaO Gram	P ₂ O ₅ Gram	Fe Gram	Acid	Base	
												Calories	Grams
Beef, rump, fat	13.6	1.16	.92	33	26	17.5	4.37	.003	.009	.00004	2.1	
sides, lean	7.2	2.56	1.80	64	51	30.4	9.85	.006	.227	.00148	4.0	
shoulder and clod, lean	4.8	3.35	2.71	95	77	62.7	15.67	.011	.360	.00235	7.8	
shoulder and clod, med. fat	7.0	2.28	1.66	65	56	43.5	10.87	.008	.250	.00153	5.4	
stirloin	9.6	1.67	1.46	48	41	31.5	7.87	.006	.181	.00118	3.9	
Beets, cooked	2.1		8.87		252	23.2	5.80					23.6
fresh	1.7	9.56	7.66	271	217	13.9	3.47	.06	.19	.0013		
Blackberries	2.6	6.10	6.10	173	173	9.0	2.25	.13	.13			
canned	11.2	1.43	1.43	40	40	1.3	0.32	.02	.02			
Black fish	1.8	9.79	4.09	279	116	86.8	21.70	.033	.543	.0009	10.8	
Blueberries, canned	2.6	5.98	5.98	170	170	4.1	1.02					
Blue fish	2.	7.77	3.99	220	113	87.9	21.95	.033	.549	.0009	11.	
Bouillon	0.5		33.6		952	83.8	20.95					
Brazil nuts	15.9	1.01	.51	28	14	9.8	2.45					
Bread, graham	11.9	1.35	1.35	38	38	13.7	3.42	.019	.19	.0013		
rolls, water	12.7	1.27	1.27	36	36	13.0	3.25	.007	.05	.0004		
rye	11.5	1.39	1.39	39	39	14.2	3.54					
white, average	11.8	1.34	1.34	38	38	14.0	3.50	.011	.075	.0003	2.7	
whole wheat	11.1	1.44	1.44	41	41	15.8	3.95	.016	.16	.0006	3.	
Buckwheat flour	15.8	1.01	1.01	29	29	7.4	1.85	.006	.114		2.	

Butter		34.9	0.46	0.46	13	13	.5	.13	.003	.004	.0004	5.2	6.1
Butter fish		4.4	3.61	2.06	102	59	42.1	10.52	.016	.263			
Butter milk		1.6	9.86	9.86	280	280	33.6	8.40	.415	.61			
Butter nuts		4.2	3.84	0.52	100	15	10.5	4.12					
Cabbage		1.2	13.26	11.20	376	317	20.3	5.07	.214	.28	.0035	18.	
Calf's-foot jelly		4.	4.06	4.06	115	115	19.8	4.95					
Catfish		8.8	1.80	1.45	51	41	23.7	5.92	.009	.148	.0002	3.	
Carrots		1.6	10.08	7.80	286	221	9.7	2.42	.168	.22	.0016		24.
Cauliflower		1.4	11.57	11.57	328	328	23.6	5.90	.55	.45			17.4
Celery		.7	23.67	10.07	671	540	23.7	4.92	.54	.54	.0027		42.2
Celery soup, canned		2.4	6.00	6.00	187	187	15.6	3.90					
Chard		1.7	9.23	9.23	202	262	33.5	8.37	.58	.24			41.1
Cheese, cheddar		20.8	.77		22		24.2	6.05	.25	.39		1.2	
cottage		5.0	3.21		91		76.2	19.05	.3	.40			
Neufchâtel		14.8	1.08		31		22.8	5.70					
Roquefort		16.5	.07		28		24.9	6.22					
Swiss		19.5	.82		23		25.7	6.42					
Cherries, fresh		3.4	4.74	4.52	134	128	4.8	1.20	.04	.09			7.8
canned		15.9	1.01	1.01	20	29	.6	.15					
Chestnuts, dried		4.1	3.93	3.93	112	112	4.9	1.22					
fresh		13.9	1.15	0.87	33	25	10.6	2.65	.017	.08	.0004		3.2
Chicken, broilers		9.2	1.74	1.46	49	41	10.2	2.55	.016	.08	.0004	10.	3.1
Chocolate		2.9	5.53	3.27	157	93	70.6	19.90	.007	.25			
Citron		27.7	.58	.58	16	16	8.4	2.10	.02	.14			
Clams, long		14.9	1.08	1.08	31	31	.6	.15	.052	.024			3.
round		1.2	13.89	8.12	394	230	79.3	10.82					
			7.61		216	216	56.0	14.00					

FOOD MATERIAL	POR- TIONS IN ONE POUND AS PUR- CHASED	WEIGHT IN OUNCES		WEIGHT IN GRAMS		AMOUNT OF				EXCESS OF		
		As pur- chased	Edible Portion	As pur- chased	Edible portion	Protein		CaO Gram	P ₂ O ₅ Gram	Fe Gram	Acid	Base
						Calories	Grams					
Cocoa	22.5	.71	.71	20	20	17.4	4.35	.027	.22	.0005		.1
Coconut prepared	30.3	.53	.53	15	15	3.8	0.95					1.2
Coconuts	14	1.17	.60	33	17	3.9	0.97	.015	.063	.0009	12.	
Cod, dressed	2.1	7.63		216		96.0	24.00	.036	.600	.0010	12.1	
salted	3.6	4.43	3.38	126	96	97.3	24.32	.036	.601			
Consommé, canned	0.5	30.40	30.40	862	862	86.2	21.55					
Corn, canned	4.4	3.60	3.60	102	102	11.5	2.87					
green	1.7	9.00	3.49	255	99	12.2	3.05	.008	.21	.00075	1.8	
Corn meal	16.2	0.99	0.99	28	28	10.4	2.60	.004	.08	.0003	1.5	
Corn flakes	16.3	.99	.99	28	28	6.1	1.52					
Corn flour	16.0	.99	.99	28	28	8.0	2.00					
Corn starch	16.3	.99	.99	28	28	*	*	*	*	*	*	*
Cottolene	40.8	.39	.39	11	11	*	*	*	*	*	*	*
Cowpeas, dried	15.5	1.03	1.03	29	29	24.8	6.20	.05	.29			
green		2.68		76	76	28.6	7.15					
Crackers, Boston	18.4	.87	.87	25	25	11.0	2.75					
graham	19.	.84	.84	24	24	9.5	2.37					
oyster	19.	.84	.84	24	24	10.7	2.67					
saltines	19.5	.82	.82	23	23	9.8	2.45					
soda	18.8	.85	.85	24	24	9.5	2.37	.006	.054	.00035	2.	

Crackers, water.	18.6	.89	.89	25	25	11.8	2.95	.051	.06	.0013	3.7
Cranberries	2.1	7.57	7.57	215	215	3.4	0.85	.07	.10	.0001	.3
Cream, 18.5% fat	8.8	1.81	1.81	51	51	5.1	1.27	.03	.045	.00005	.1
40% fat	17.3	.93	.93	26	26	2.3	.57	.12	.45		45.5
Cucumbers, fresh	0.7	23.53	20.28	667	575	18.4	4.60				
pickles	0.7	22.76	22.76	645	645	12.9	3.22	.04	.09		1.8
Currants, dried (Zante)	14.6	1.10		31		3.0	0.75	.09	.17	.0009	
fresh	2.6	6.17		175		10.5	2.62	.03	.03	.001	3.2
Dates.	14.2	1.13	1.02	32	29	2.4	.60	.06	.24	.0019	7.5
Doughnuts	19.4	.82	.82	23	23	6.2	1.55	.028	.05	.0002	9.5
Eggs, whole	6.	2.69	2.38	76	68	36.2	9.05	.05	.27	.0023	7.0
white	2.3		6.92		196	96.5	24.12	.018	.298	.0005	6.
yolk	16.4		.97	81	64	47.6	11.90				
Eels, dressed.	5.6	2.85	2.26		28	17.3	4.32				
Egg plant			12.64		358	17.2	4.30				
Farina	16.4	.97	.97	28	28	12.2	3.05	.089	.099	.0010	32.3
Figs, dried	14.4	1.12		32		5.4	1.35				
Fig bars	16.2	.99	.99	28	28	5.2	1.30				
Filberts	15.3	1.05	.50	30	14	8.8	2.20				
Flounder (entrails removed)	1.1	12.45		350		90.4	22.60	.034	.545	.0009	11.3
Flour, rye	15.9	1.01	1.01	29	29	7.8	1.95	.01	.12		3.3
wheat, entire.	16.3	.98	.98	27	27	15.4	3.85				
wheat, graham	16.3	1.00	1.00	28	28	12.7	3.17	.005	.04	.0004	2.7
wheat, patent	16.2	1.00	1.00	28	28	12.7	3.17	.007	.05	.0004	2.7
wheat, straight	16.1	1.00	1.00	28	28	12.1	3.02	.007	.05		
wheat, average high and medium grades	16.1	1.00	1.00	28	28	12.8	3.20	.007	.05	.0004	2.7

FOOD MATERIAL	POR- TIONS IN ONE POUND AS PUR- CHASED	WEIGHT IN OUNCES		WEIGHT IN GRAMS		AMOUNT OF			EXCESS OF			
		As pur- chased	Edible portion	As pur- chased	Edible portion	Protein Calories	CaO Gram	P ₂ O ₅ Gram	Fe Gram	Acid	Base	
Flour, wheat, low grade . .	16.3	1.00	1.00	28	28	15.7	3.02	.01	.10	.0013	4.6	
Fowl	7.5	2.13	1.58	60	45	34.5	8.62	.006	.108			
Frog's legs	2.0	8.12	5.53	233	157	97.2	24.30	.042	.67			
Gelatin	16.6	.96	.96	27	27	99.8	24.95					
Ginger, crystallized . . .	15.8	1.02	1.02	20	20	.4	.10					
Ginger snaps	18.5	.86	.86	25	25	6.4	1.60	.003	.096	.0006	2.	
Goose, young	14.6	1.10	.90	31	20	16.7	4.17					
Grape butter	10.9	1.48	1.48	42	42	2.0	.50	.024	.12	.0013		2.8
Grapes	3.3	4.87	3.66	138	104	5.4	1.35	.021	.04			4.0
Grape juice	4.5	3.53	3.53	100	100					.0044		
Greens, dandelion	2.7	5.78	5.78	164	164	15.7	3.92	.04	.601	.0010	12.	
Haddock (entrails removed)	1.6	9.96	4.04	283	139	96.2	24.05	.037	.613	.0010	12.2	
Haddock, smoked	3.2	5.50	3.71	156	105	98.1	24.52	.014	.228	.0004	4.7	
Halibut, smoked	9.2	1.74	1.62	49	46	38.0	9.50	.014	.228	.0004	4.7	
Halibut, steaks	4.5	3.49	2.93	99	83	61.4	15.35	.023	.384	.0006	7.8	
Ham, fresh lean	10.3	1.55	1.55	44	44	44.0	11.00	.082	.253	.0017	5.5	
med. fat	13.	1.23	1.10	35	31	19.0	4.75	.004	.108	.0007	2.3	
smoked, lean	10.7	1.49	1.32	42	38	29.7	7.42	.006	.171	.0011	3.7	
smoked, med. fat	10.	.98	.85	28	24	15.7	3.92	.003	.090	.0006	2.	
boneless	13.8	1.16	1.16	33	33	18.8	4.70	.004	.108	.0007	2.3	

Ham, deviled		17.4	.02	.02	26	26	19.8	4.95	.004	.114	.0007	2.5	
Head cheese		13.2	1.21	.02	34	26	20.4	5.10	.019	.318	.0005	6.3	
Herring, smoked		7.3	2.19	1.22	62	35	50.9	12.72	.020	.344	.0005	6.8	
whole		3.6	4.25	2.49	125	71	55.0	13.75					
Hickory nuts		12.2	1.31	.49	37	14	8.6	2.15					
Hominy		16.1	1.00	1.00	28	28	9.4	2.35					
Honey		14.8	1.08	1.08	31	31	.5	.12	.001	.01	.0003		
Huckleberries		3.4	4.76		135		3.3	.82	.046	.09	.0014		
Koumiss		2.3	6.82	6.82	193	193	21.7	5.42	.272	.345	.00038		2.9
Lamb, breast		10.6	1.51	1.22	43	35	26.4	6.60	.004	.152	.001	3.3	
chops, broiled		14.2	1.13	.99	32	28	24.4	6.10	.005	.140	.0009	3.	
fore quarter		11.2	1.41	1.16	40	33	24.2	6.05	.005	.139	.0009	3.	
hind quarter		9.5	1.69	1.41	48	40	31.4	7.85	.006	.180	.0012	3.9	
leg, med. fat		8.4	1.90	1.57	54	44	34.1	8.52	.006	.196	.0013	4.2	
loin		12.7	1.26	1.06	36	30	22.7	5.67	.004	.130	.0010	2.8	
neck		11.0	1.46	1.20	41	34	24.1	6.02	.005	.138	.0009	3.	
shoulder		12.3	1.31	1.04	37	29	21.3	5.32	.004	.122	.0008	2.6	
side		10.2	1.59	1.27	45	36	25.4	6.35	.005	.146	.0010	3.1	
tongue		9.5	1.68		48		25.8	6.45	.005	.148	.0010	3.2	
Lard		40.9	.39	.39	11	11	*	*	*	*	*	*	
Lemons		1.4	11.41	7.96	324	226	9.0	2.25	.12	.04	.0013		12.
Lemon juice		1.8	9.00	9.00	255	255	*	*	.083	.063			11.
Lentils		15.8	1.01	1.01	29	29	29.5	7.37	.04	.29	.0024	1.5	
Lettuce		0.7	22.32	18.47	633	524	25.1	6.27	.26	.47	.005		38.6
Lobster		1.3	11.48	4.23	326	120	78.6	19.65					
canned		3.8	4.30		119		85.9	21.47					
Macaroni		16.3	.09	.09	28	28	14.8	3.70					

FOOD MATERIAL		POR- TIONS IN ONE POUND AS PUR- CHASED	WEIGHT IN OUNCES		WEIGHT IN GRAMS		AMOUNT OF			EXCESS OF			
			As pur- chased	Edible portion	As pur- chased	Edible portion	Protein		CaO Gram	P ₂ O ₅ Gram	Fe Gram	Acid	Base
							Calories	Grams					
Mackerel, fresh	3.6	4.49	2.54	127	72	53.9	13.47	.020	.337	.0005	6.7		
salt	10.0	1.43	1.15	41	33	22.6	5.65	.008	.136	.0002	2.8		
salt, canned	7.0	2.25		64		50.0	12.50	.019	.312	.0005	6.2		
Marmalade, orange	15.5	1.02	1.02	29	29	0.7	.17	.001	.009	.00007		.1	
Milk, condensed, sweetened	14.8	1.08	1.08	31	31	10.8	2.70	.135	.172	.00019		1.4	
condensed, unsweetened	7.5	2.11	2.11	59	59	23.0	5.75	.264	.335	.00037		2.7	
skimmed	1.6	9.61	9.61	273	273	37.0	9.25	.465	.599	.00066		5.0	
whole	3.1	5.10	5.10	145	145	19.0	4.75	.239	.303	.00034		2.6	
Molasses	13.0	1.23	1.23	35	35	3.3	.83	.3	.1			20.8	
Mushrooms	2.0	7.86		223		31.2	7.80	.053	.53			8.9	
Muskmelons	.9	18.00	8.91	510	252	6.0	1.50	.06	.078	.00075		19.	
Mutton, chuck	14.4	1.11	.91	32	26	15.0	3.75	.003	.086	.0006	2.		
flank, med. fat	17.5	.91	.87	26	25	15.0	3.75	.003	.086	.0006	2.		
fore quarter	12.2	1.30	1.02	37	29	18.0	4.50	.003	.104	.0007	2.5		
hindquarter	9.5	1.34	1.09	38	31	20.7	5.17	.004	.119	.0008	2.5		
hind leg, lean	7.2	2.22	1.85	63	52	41.5	10.37	.008	.239	.0016	5.		
hind leg, med. fat	8.7	1.83	1.50	52	42	31.4	7.85	.006	.181	.0012	4.		
loin, med. fat	14.0	1.14	.97	32	28	17.7	4.42	.003	.102	.0007	2.2		
neck, med. fat	9.5	1.68	1.22	48	35	23.4	5.85	.004	.135	.0009	3.		
shoulder, med. fat	8.8	1.82	1.41	52	40	28.3	7.07	.005	.163	.0011	3.5		

Mutton, side	10.1	1.30	1.06	37	30	19.4	4.85	.004	.112	.0007	2.5
Nectarines	2.7	5.71	5.34	162	152	3.6	.90				
Oat meal, rolled oats	18.1	.88	.88	25	25	16.1	4.02	.03	.216	.0009	3.
Okra	1.5	10.54	10.54	299	299	16.8	4.20				
Oleomargarine	34.1	.47	.47	13	13	6.	0.15				
Olives	10.	1.61	1.18	46	33	1.5	0.37	.06	.01	.0009	18.8
Onions	2.0	8.03	7.24	228	205	13.2	3.30	.12	.24	.0011	3.1
Oranges	1.7	9.45	6.86	268	195	6.2	1.55	.11	.09	.0006	11.
Orange juice	2.	8.17	8.17	232	232	*	*	.12	.07		14.4
Oysters, fresh, solids	2.3	7.00	7.00	198	198	40.2	12.30	.12	.74		30.
canned	3.3	4.87	5.43	138	154	48.6	12.15	.14	.29		18.2
Parsnips	2.4	6.78	6.91	196	196	9.9	2.47				
Pea soup, canned	2.3	6.01	6.01	196	196	28.2	7.05				
Peaches, canned	2.1	7.50	7.50	213	213	5.9	1.47	.017	.097	.0006	10.
fresh	1.5	10.47	8.53	297	242	6.8	1.70	.02	.113	.0007	12.2
Peanuts	8.8	.85	.64	24	18	18.8	4.70	.018	.160	.00035	.7
Peanut butter	27.4	.58	.58	16	16	19.4	4.85	[.018]	[.160]	[.00035]	
Pears, fresh	2.5	6.25	5.57	177	158	3.8	.95	.032	.09	.0005	5.6
canned	3.4	4.65	4.65	132	132	1.6	.40	.013	.004	.0002	2.3
Peas, canned	2.5	6.37	6.37	181	181	26.1	6.52	.04	.25	.0015	1.5
dried	16.1	.99	.99	28	28	27.7	6.92	.04	.25	.0015	1.5
green	2.5	6.37	3.52	180	100	28.0	7.00	.032	.24	.0016	1.2
Pecans	17.9	.89	.48	25	14	5.2	1.30				
Perch	2.6	6.32	1.74	37	37	89.0	22.25	.033	.646	.0009	11.1
Pies, apple	12.3	1.30	1.30	37	37	4.6	1.15				
custard	8.0	1.98	1.98	56	56	9.4	2.35				
lemon	11.6	1.38	1.38	39	39	5.6	1.40				

FOOD MATERIAL	POR- TIONS IN ONE POUND AS PUR- CHASED	WEIGHT IN OUNCES		WEIGHT IN GRAMS		AMOUNT OF				EXCESS OF		
		As pur- chased	Edible portion	As pur- chased	Edible portion	Protein		CaO Gram	P ₂ O ₅ Gram	Fe Gram	Acid	Base
						Calories	Grams					
Pies, squash	8.2	1.98	1.98	56	56	9.8	2.46	.02	.08	.0011		15.7
Pineapple, fresh canned	7.0	2.30	8.18	65	232	3.7	.92	.04	.14			
Pine nuts, shelled	27.5	.58	.58	17	17	22.3	5.57					
Pistachios, shelled	20.0	.55	.55	16	16	13.9	3.47					
Plums	3.6	4.41	4.18	125	118	4.8	1.20	.029	.064	.0006		7.3
Porgy, whole	2.2	7.27	2.93	206	83	61.9	15.47	.022	.391	.0006	7.8	
Pork, loin chops, lean loin chop, med. fat	9.	1.83	1.40	52	40	32.2	8.05	.006	.185	.0012	4.	
fat, salt	12.3	1.30	1.04	37	30	19.7	4.92	.004	.113	.0007	2.5	
side, not lard and kidney shoulder, smoked	35.5	.45	.45	13	13	1.0	.25	.0002	.005	.00004	0.1	
sausage	21.4	.75	.66	21	19	6.8	1.70	.001	.039	.0003	0.8	
tenderloin	13.	1.21	.99	34	28	17.9	4.47	.003	.103	.0007	2.2	
Potatoes	20.5	.78	.78	22	22	11.4	2.85	.002	.066	.0004	1.4	
Potato chips	8.8	1.83	1.83	52	52	39.2	9.80	.007	.225	.0014	4.9	8.6
Potatoes, sweet	3.0	5.27	4.23	150	120	10.6	2.65	.019	.166	.0015		3.9
Prunes, dried	26.0	.62	.62	17	17	4.8	1.20	.008	.072	.00068		5.4
Pumpkins	4.5	3.58	2.86*	101	81	5.8	1.45	.020	.08	.0004		8.
Radishes	11.6	1.37	1.17	39	33	2.8	.70	.02	.08	.0009		5.7
	0.6	26.52	13.72	752	389	15.6	3.90	.11	.42			9.8
	1.3	17.21	12.04	488	341	17.7	4.42	.17	.30	.0020		

Raisins	14.0	1.14	1.02	32	20	3.0	.75	.02	.08	.001	6.8
Raspberries	3.0	5.33	5.33	151	151	10.3	2.57	.11	.18		
Raspberry juice	2.	9.38	9.38	266	266	*	*	.08	.08		13.
Rhubarb	0.6	25.20	15.27	714	433	10.4	2.60	.26	.30		37.
Rice	15.9	1.01	1.01	29	29	9.1	2.27	.003	.057	.0003	2.7
Rice flour	16.4	.07	.07	28	28	9.5	2.37	.003	.057	.0003	2.7
Rutabagas	1.	12.37	8.62	351	246	12.6	3.15	.2	.31		
Salmon, fresh	6.4	2.50	1.75	71	49	43.3	10.82	.016	.270	.0004	5.4
canned	6.6	2.41	1.80	69	51	44.5	11.12	.017	.278	.0004	5.5
Sausage, bologna	11.4	1.50	1.50	43	43	31.9	7.07	.006	.183	.0012	4.
frankfort	11.3	1.12	1.12	40	40	31.3	7.82	.006	.180	.0012	3.9
summer	21.6	0.74	0.70	21	20	20.6	5.15	.004	.118	.0012	2.5
Sardines	9.2	1.73	1.31	49	37	34.2	8.55	.013	.134	.0003	4.2
Scallops	3.3	4.79	4.79	135	135	80.3	20.07				
Shad	3.6	4.37	2.10	124	62	46.8	11.70	.018	.203	.0005	5.8
Shad roe	5.8	2.75	2.75	78	78	65.2	16.30				
Shredded wheat	16.6	.07	.07	27	27	14.0	3.50	.016	.243	.0014	3.3
Shrimp, canned	5.0	3.17	4.07	90		90.8	22.70				
Smelt	2.2	7.14	4.07	202	116	81.3	20.32	.030	.508	.0008	10.1
Spinach	1.0	15.62	14.76	443	418	35.2	8.80	.37	.54	.0133	113.
Squash	1.7	9.53	7.65	217	217	12.2	3.05	.054	.08	.0017	6.1
Strawberries	0.9	17.60	9.04	270	256	10.2	2.55	.13	.162	.0023	
Strawberry juice	3.3	4.72	17.60	500	500	80.9					
Sturgeon, anterior sections	18.2	.88	3.94	134	112	*	20.22	.030	.505	.0008	10.
Sugar, granulated	15.0	1.07	.88	25	25	*	*	*	*	*	*
maple	17.2	.93	1.07	30	30						
brown			.93	26	26						

FOOD MATERIAL	POR- TIONS IN ONE POUND AS PUR- CHASED	WEIGHT IN OUNCES		WEIGHT IN GRAMS		AMOUNT OF				EXCESS OF		
		As pur- chased	Edible portion	As pur- chased	Edible portion	Protein		CaO Gram	P ₂ O ₅ Gram	Fe Gram	Acid	Base
						Calories	Grams					
Tapioca	16.	.99	.99	28	28	.4	.10	*	*	*	*	*
Terrapin	1.3	12.20	3.03	346	86	72.9	18.22					
Tomatoes, canned fresh	1.	15.63	15.63	443	443	21.2	5.30			.0017		24.5
Tripe	2.6	15.47	15.47	439	439	15.8	3.95	.087	.257			
		6.12		174		81.2	20.30					
Trout, salmon	3.7	4.29	2.15	122	61	43.4	10.85	.016	.271	.0004	5.4	
Turkey	10.4	1.53	1.21	44	34	29.0	7.25	.005	.167	.0011	3.6	
Turtle, green	.9	17.90	4.21	508	119	94.6	23.65					
Turnips	1.8	12.92	8.95	366	254	13.2	3.30	.222	.292	.0013		7.
Vanilla wafers	19.9	.80	.80	23	23	6.0	1.50					
Veal, breast, lean	5.	2.97	2.25	84	64	54.1	13.52	.010	.311	.0011	6.7	
Least, med. fat	7.	2.19	1.75	62	50	38.4	9.60	.007	.221	.0014	4.8	
chuck, lean	3.6	4.34	3.54	132	101	82.8	20.70	.016	.476	.0031	10.3	
chuck, med. fat	6.	3.18	2.57	90	78	57.4	14.35	.011	.330	.0022	7.1	
flank, med. fat	8.	2.01	2.01	60	60	46.6	11.65	.009	.268	.0017	5.8	
kidney	5.6	2.82	2.82	80	80	54.0	13.50	.010	.311	.0020	6.7	
leg, lean	5.	3.18	2.89	90	81	69.8	17.45	.013	.401	.0036	8.7	
leg, med. fat	6.	2.65	2.18	75	62	49.9	12.47	.009	.287	.0019	6.2	
liver	5.6	2.85	2.85	81	81	61.4	15.35	.012	.353	.0023	7.6	
loin, lean	4.6	3.42	2.67	97	76	61.8	15.45	.012	.355	.0023	7.7	

Veal, loin, med. fat	6.6	2.39	1.99	68	57	45.0	11.25	.008	.259	.0017	5.6
neck	4.4	3.63	2.47	103	70	50.8	14.20	.011	.327	.0021	7.1
rib, med. fat	4.6	3.41	2.56	97	73	60.1	15.02	.011	.345	.0023	7.5
rump	7.	2.25	1.57	64	44	35.2	8.80	.007	.202	.0013	4.4
shank, fore	3.4	4.60	2.72	130	77	63.9	15.97	.012	.367	.0024	7.9
shank, hind	2.	7.65	2.84	217	81	66.6	16.65	.012	.383	.0025	8.3
shoulder, lean	4.6	3.43	2.84	97	81	66.7	16.67	.013	.383	.0025	8.3
shoulder, med. fat	7.	2.21	1.69	63	48	37.8	9.45	.007	.217	.0014	4.7
Vegetable soup	0.6	25.83	25.83	735	735	85.2	21.30	.18	.8	.00029	1.1
Walnuts, California black	8.6	1.86	.50	53	14	10.4	2.60	.015	.108		
Watermelons	7.8	2.05	.53	58	15	16.6	4.15	.06	.06		8.8
Weak fish	.6	28.22	11.68	800	331	5.3	1.32				
Wheat, cracked	2.0	7.96	3.80	226	108	76.7	19.17	.029	.479	.0008	9.6
Whey	16.4	.97	.97	28	28	12.3	3.07	.016	.243	.0014	3.3
White fish	1.2	13.20	13.20	375	375	15.0	3.75				
White fish	3.2	5.08	2.35	144	67	61.0	15.25	.023	.381	.0006	7.6
Zwiebach	19.1	.84	.84	24	24	9.3	2.32				

* In these cases the amounts are assumed to be negligible.

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